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IMPACTS OF GREAT SALT LAKE WATER LEVEL MANAGEMENT ON THE UTAH TEST AND TRAINING RANGE

BOX ELDER AND TOOELE COUNTIES, UTAH

July 1985

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Air Force Logistics Command
Wright Patterson AFB, Ohio

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1. INTRODUCTION

1.1 BACKGROUND

The State of Utah is considering the use of public lands administered by the Bureau of Land Management (BLM), as well as lands (the Utah Test and Training Range) administered by the Department of Defense (Air Force) for alleviating flooding problems associated with the Great Salt Lake. These federal agencies have determined that the proposed use of their lands may have significant impacts on the human environment, and that consequently an environmental impact statement (EIS) is needed. As stated in the Memorandum of Understanding between BLM, the Air Force and the Utah Division of State Lands and Forestry, the BLM is the lead agency for preparing the EIS and the Air Force is the cooperating agency. The Air Force will not consider permitting use of its land until it has considered the impacts of the State's proposals on operations at the Utah Test and Training Range (UTTR).

The purpose of this document is to provide the Air Force with an assessment of the impacts of Great Salt Lake Water Level Management alternatives on Air Force operations at the Utah Test and Training Range (UTTR), and in conjunction to serve as the basis for the Air Force's contribution to the EIS. This report also includes a review of state-funded contractor studies on UTTR meteorology and geohydrology, and a review of the costs developed by the state for lake level management.

Cost is an important criterion that the Air Force will use to judge the significance of anticipated impacts to UTTR operations from proposed lake level management schemes. Where possible, cost estimates of some of the impacts identified in this document have been prepared. The cost estimates should be viewed as broad-based approximations prepared to gauge the

significance of a given potential impact; these numbers should not be added to attempt to arrive at a total cost of lake level management to the Air Force because they may be based on different assumptions and because costs were not derived for all impacts. Also, estimated costs of some mitigation measures have been developed.

This report is based primarily on impact assessment documents prepared by Air Force Major Commands (MAJCOMs) and UTTR users. Section 1 presents an overview of the Great Salt Lake flooding problem and proposed solutions. The existing natural environment of the UTTR and the Air Force operations are described in Section 2. Section 3 presents a preliminary assessment of the potential impacts of the proposal on the natural environment and on the UTTR operations. A summary of impacts, conclusions reached, and mitigation measures that could be needed are described in Section 4.

1.2 DESCRIPTION OF FLOODING PROBLEM

The Great Salt Lake is the lowest water surface in a large, topographically-closed basin that has no outlet. Any water falling into the basin either evaporates, recharges groundwater, or flows into the Great Salt Lake. Changes in precipitation in the basin, groundwater recharge and evaporation thus influence the surface level of the lake. Historically, the Great Salt Lake surface level has varied from a low of 4191.35 ft in 1963 to a high of about 4211.5 ft in 1873. There is evidence to suggest that the lake level has been as high as 4217 ft within the last 400 years (Currey, et al. 1984). The lake level is directly determined by inflow from three sources (surface water, groundwater and direct precipitation on the lake)

and by outflow from evaporation. Typically, about 66% of the inflow is from surface streams, 31% from direct precipitation and 3% from groundwater (Currey, et al 1984).

Since the recorded low in 1963, the lake level has generally risen, primarily in response to a general increase in precipitation over the same time period, also, in recent years, evaporation has been less than the long term average. From 1963 to 1976, the surface level of the Great Salt Lake increased 11 ft to about 4202 ft; (about 0.8 ft/yr) from 1976 to 1979 the level dropped about 4 ft to around 4198 ft. It then rose approximately another 11 ft from 1979 to 1984 (USGS 1985). In 1985, the lake level peaked at 4209.9 ft. The long-term (past 110 years) average rainfall for the Salt Lake area is about 15 inches. The 1981-1982 water year (October 1 to September 30) was the wettest on record with slightly over 25 inches, the 1982-1983 water year also measured above normal at about 21 inches, and in water year 1983-1984, a precipitation level of almost 24 inches was recorded. Over the period 1981-1984, annual rainfall in the Salt Lake vicinity has averaged about 20 inches, almost 5 inches higher than the long-term average (Christensen 1985).*

On the other hand, recent meteorological conditions suggest that Salt Lake City weather patterns may be returning to the long term average.

*Analysis of 2,000 years of tree ring data for the Colorado Plateau (northern Arizona, southeastern Utah and eastern Colorado) indicates that long-term (30-40 yr) wet cycles typically follow droughts, and that beginning in 1970 the regional climate may have begun a wet cycle following a 1941-1970 period of below-average moisture (Richardson 1977). The extent to which tree ring data from the Colorado Plateau correlate with Great Salt Lake levels is unclear, however, and a direct relationship may not exist.

Precipitation and temperature data recorded at Salt Lake City International Airport show that April 1985 is the third driest and third warmest on record. The precipitation total for the 1984-1985 water year (through June 1985) is about 14.9 inches, which is about 1.7 inches above the 30 year average for the same time period (Oct.-June). In mid-April, the snowpack in the mountains around the area was only about 75-90% of normal, which indicates that runoff from snow melt would also be reduced. The lake level for the 1984-1985 water year peaked at 4209.9 ft in May 1985. These conditions suggest that the potential for continued flooding from the Great Salt Lake may be considerably less than previously anticipated.

1.3 WATER LEVEL MANAGEMENT ALTERNATIVES

Many projects have been proposed to deal with controlling/managing the lake elevation. These include (a) diversion of inflow from the major river sources to other drainage basins, (b) expanded upstream storage reservoirs together with increased agricultural use of fresh water, (c) increased diking along the shoreline of the Great Salt Lake to protect property, (d) pumping the lake waters into ponds in the desert west of the lake (West Desert Pumping) to increase evaporation, (e) pumping excess waters to Puddle Valley in combination with portions of the other options, and (f) pumping to BLM lands only, in combination with other options excluding Air Force property. The amount each affects lake elevation varies widely, depending on whether (1) they are directed to high or low water levels; (2) they are effective for short periods of high inflow or most effective over a long period; or (3) they use reduction of inflow, exports, evaporation or storage as a means of controlling the lake elevation.

Two conclusions reached by the State in studying the problem are that the types of projects that have the best potential to deal with the problem of high lake levels are those that can be used year after year as long as the problem persists, and that any proposal to deal with high lake levels would have to dispose of large volumes of water in a relatively short period of time (UDSLF 1984).

The State is concerned that future increases in the level of the Great Salt Lake, although extremely unlikely, will cause flooding damage to public and private interests. According to one study, the rising lake level during 1983 and 1984 caused an estimated $176 million in property damage and mitigation costs (UDSLF 1984). However, continued annual increases in the lake level are less likely. A time series analysis of historical lake level changes conducted by James et al. (1984) predicted probabilities of the annual high lake level *exceeding* various stages at least once, as indicated below:

Year	Probability Exceeding Lake Level 4208 ft	4212 ft	4215 ft	4218 ft
1985	0.31	0.02	0.00	0.00
1990	0.41	0.07	0.01	0.00
2000	0.46	0.09	0.01	0.00
2010	0.48	0.10	0.01	0.00
2030	0.54	0.11	0.01	0.00

Probabilities drop to zero for all years at a lake level of 4218. As shown, based on historical data, there is a 10% chance of the lake level reaching 4212 ft at least once by the year 2010. Although considerable flooding damage has occurred in the past, historical data on lake level increases suggest that additional increases to higher lake levels are not likely.

Based on the recent upward trend of the lake elevation and projections that some additional rise could occur, lake-level management to mitigate ongoing flooding of properties and facilities along the eastern and southern shoreline of the Great Salt Lake has received serious consideration by the State. The low 1984-1985 water year precipitation levels suggest that the weather patterns and lake levels may be returning to the long term average, and that the upward trend is not as pronounced; however, the state is still examining lake level alternatives at the present. Although many alternatives have been considered, options involving West Desert Pumping have been identified by the State as being the most feasible near-term means of affecting the lake level (under the assumed scenario of continued lake rise).

West Desert Pumping is a plan to pump water from the Great Salt Lake (south arm) into the desert west of the Great Salt Lake in order to increase the area for evaporation. Several designs involving an intake canal, pumping station, dikes to direct flow and contain the water, and a discharge canal have been evaluated as discussed below (Sects. 1.3.1 and 1.3.2). Concentrated brine would be returned by gravity flow to the Great Salt Lake.

The rapid rise in the level of the lake in 1983 and 1984, which in comparison to historical data on the lake level appears to be a rare event, has focused attention on initiating flooding mitigation measures. The State wishes to be prepared to implement the West Desert Pumping option at the earliest possible date in an effort to reduce what some believe to be a rising lake level. This is being given further consideration. The State also intends to undertake and complete on an emergency basis, specific

diking measures to protect certain critical facilities and public properties (if the lake level continues to rise), in conjunction with West Desert Pumping. Much diking has already been completed, contracts have been let for work in 1985, and more is planned for the immediate future (UDSLF 1984). The West Desert Pumping Proposal would take about two years to engineer and construct, and would be operational for about thirty years.

The State feels that shoreline diking and West Desert Pumping complement each other as being the most feasible and cost effective means of dealing with the short-term rising level of the Great Salt Lake (UDSLF 1984). Long range lake level management alternatives are also being evaluated by the State; these are discussed in Sect. 1.3.4.

The State feels that the benefits of West Desert pumping (reduced damage from flooding) outweigh its costs. According to one study, the lake caused $176 million in damage when it rose to a level of 4209 ft in 1983. The estimated construction cost of West Desert pumping, including assumed costs for contingency and overhead, is about $75 million at the feasibility design stage (Eckhoff et al. 1985). Estimated costs could increase as the design work continues, and could be as high as $100 million (Appendix C). Thus, the costs of West Desert pumping could approach the estimated benefits, which makes the project less attractive.

1.3.1 State's Preferred West Desert Pumping Option

As shown in Fig. 1, the State's preferred option would consist of two evaporation ponds (East Pond and West Pond) covering an area of about 460,000 acres. Also shown is the boundary of the North Range of the UTTR (see Sect. 2.2 for a more complete description of the UTTR). This option would affect, through construction or intermittent inundation, some 200,000

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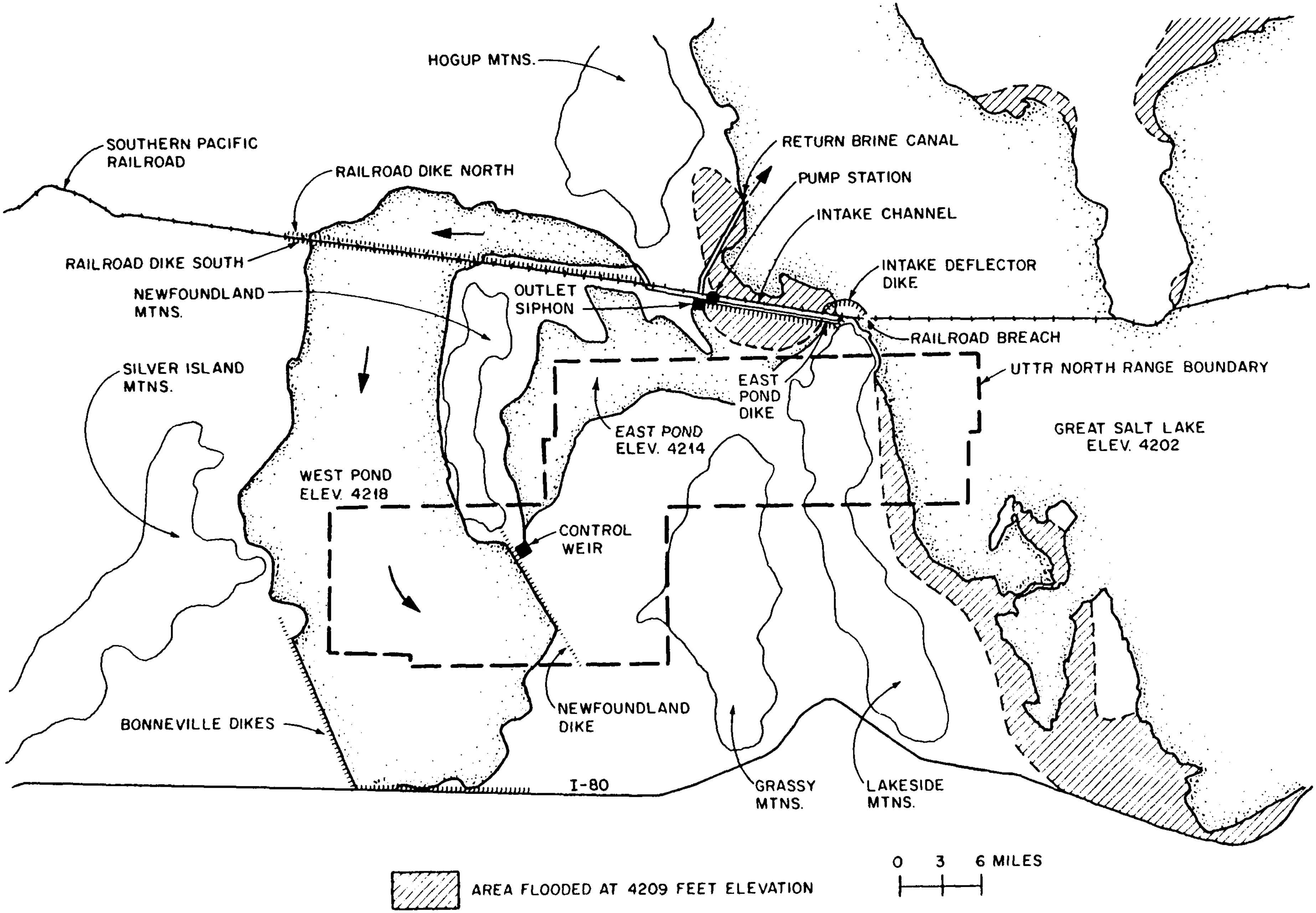

Figure 1. Map of state's preferred option for implementing West Desert Pumping

acres of Bureau of Land Management land, 180,000 acres of Department of Defense land (UTTR), 20,000 acres of State land and 60,000 acres of private land. These ponds would permit evaporation of slightly more than 1,000,000 acre-feet of water per year (Eckhoff 1983). The details of the West Desert Pumping project are still being developed, and the current version of the project may not match that described in this report.

The major elements of the preferred West Desert Pumping option as outlined in March 1985 are (Eckhoff 1985):

1. An intake deflector dike that will direct flow of water from the South Arm of the Great Salt Lake toward the intake channel near Lakeside. The Southern Pacific Railroad causeway dividing the lake into North and South Arms was breached near Lakeside in August 1984 to permit flow from the higher elevation South Arm into the North Arm.

2. An intake channel and east barrier dike along the south side of the Southern Pacific Railroad (SPRR) track from Lakeside to the pump station on the east side of Hogup Ridge. The water flows under the tracks at Lakeside from the north side through existing openings. The dike separates the intake channel from the East Pond.

4. A Pump Station containing four diesel-powered vertical pumps capable of pumping about 2,400 cfs of water from the lake level to the West Pond level. The daily transfer at this pumping rate is about 4,800 acre-feet.

   A pump station discharge channel (cut through Hogup Ridge) would carry the flow from the pump station to the West Pond, which would be the higher of the two ponds. This canal would also pass

under the railroad along the west flank of Hogup Ridge to permit discharge into a portion of West Pond north of the railroad embankment.

5. The West Pond, which is the primary evaporation area, will have estimated surface area of about 374,000 acres at an elevation of 4218 ft (MSL) and the capacity to evaporate approximately 840,000 acre-feet of water per year. The storage volume of this pond is about 1,100,000 acre-feet at an average depth of 2.92 ft.

6. Railroad barrier dikes will be constructed on the north and south sides of the SPRR track in the vicinity of the West Pond. These will be designed to protect the embankment from wave and water damage. Alternatively, the SPRR management may elect to raise the track elevation for the necessary protection.

7. The Bonneville dikes would keep West Pond water from reaching the Bonneville Salt Flats area (including Bonneville Speedway and Racetrack and commercial salt mining interests) and I-80. The northward trending end of this dike will be constructed along a natural elevated course (threshold), which is estimated to be slightly higher than 4217 ft (MSL) and currently separates the West Pond area from the Bonneville Salt Flats. Interstate 80 and adjacent surfaces may also be below the West Pond elevation (4218) in many places along this dike.

8. The Newfoundland dike separates the West and East ponds south of the Newfoundland Mountains. This dike is constructed along the course of a natural elevated course (threshold) having a minimum elevation of about 4217 ft (MSL). The high water line between the

southern end of the Newfoundland dike and the eastern end of the Bonneville dike will be determined by the topography of the existing low rise (above 4225 ft) in that area. The control weir associated with the Newfoundland dike establishes the elevation of the West Pond (4218 ft) and is the discharge structure for flow from the West Pond to the East Pond.

9. The East Pond has an estimated maximum surface area of about 88,000 acres at an elevation of 4214 ft (MSL) and a capacity to evaporate about 220,000 acre-feet of water per year. The storage volume at design level is estimated to be about 250,000 acre-feet with an average depth of about 2.7 ft.

10. The outlet siphon, which could be constructed as part of the pump station, channels water from the East Pond under the intake canal and the SPRR track to the return brine canal for discharge to the North Arm of the Great Salt Lake.

1.3.2 West Desert Pumping Alternatives

In the 1983 engineering feasibility report (Eckhoff 1983) and 1984 update (Eckhoff 1984) for the West Desert Pumping concept, the evaluations of pond designs were based on several variables that included a range of lake levels for initiating pumping, a range of evaporation areas, alternative locations for intake and discharge canals and the pump station, and alternative flow directions through the ponds (clockwise and counterclockwise).

The lake level at which pumping would begin is currently not well defined in the State's proposal, and yet is an important factor related to the potential impacts of the West Desert Pumping Proposal on the Utah Test

and Training Range. The Air Force believes that West Desert pumping if implemented, should be used to maintain a lake level of 4210 ft because this is the lake level that has already caused the recent flooding damage; i.e., the West Desert pumping should not be used to reclaim or recover areas lost to date to flooding. This should minimize the length of time that the West and East Ponds would exist, unless extremely high precipitation levels were to continue in the future, which is extremely unlikely based on historical trends of the lake level.

The State's preferred option described above provides the optimum size evaporation ponds within the physical constraints of the natural features and man-made facilities in the project area. The State's preferred option also has the capability to function up to the historic maximum lake elevation of about 4212 ft. From the feasibility studies, the State's Proposed Action Plan (UDSLF 1984) also identifies four alternative evaporation pond configurations to the State's preferred West Desert Pumping option described above. Following is a brief description of each alternative, plus other feasible variations, including key features, advantages, and disadvantages.

1.3.2.1 Bonneville Pond

The Bonneville Pond alternative differs from the State's preferred option by expanding the West Pond to inundate the Bonneville Speedway and Racetrack, the Salt Flat, and commercial salt mining interests north of I-80, while eliminating the East Pond, except for a brine return channel to the inverted siphon discharge facility (Fig. 2). The area for evaporation is similar to the preferred option. A noteworthy advantage is that less Air Force land is flooded than the State's preferred option. However, if the

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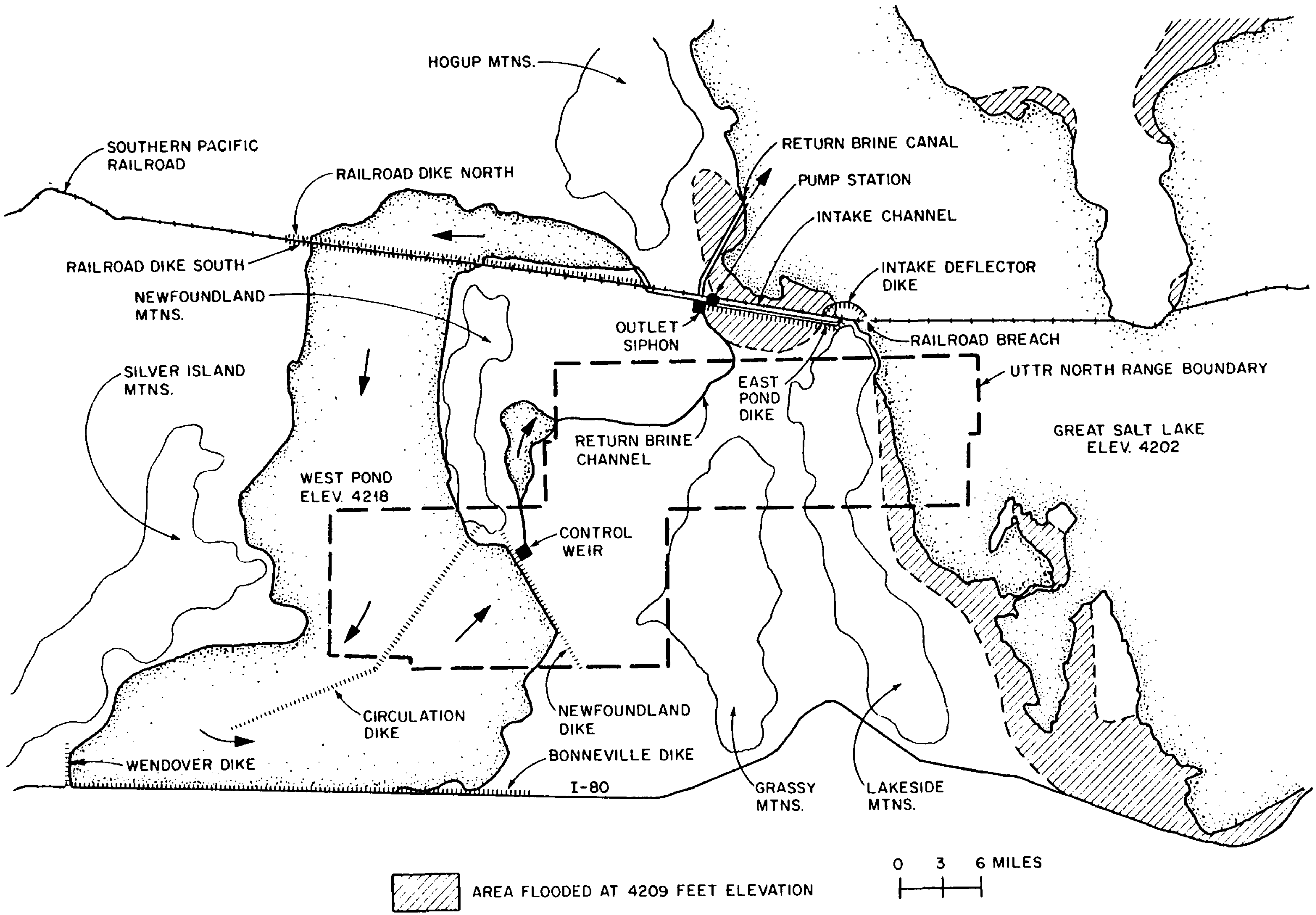

Figure 2. Map of proposed Bonneville Pond option for implementing West Desert Pumping

lake were to rise above the level of the inverted siphon the East Pond would naturally develop as the lake water enters the area through the siphon. This alternative is proposed for consideration in the EIS (BLM 1985).

1.3.2.2 Wendover Pond Alternative

The Wendover Pond alternative is significant because it would result in a pond with a larger surface area, and hence, a larger evaporation potential, than any other alternative considered (Fig. 3). The Wendover Pond includes all of the land area involved in the Bonneville Pond alternative and would also inundate Air Force lands south of I-80, and east of Wendover Bombing Range. This alternative is not receiving further consideration because of the excessive costs of protecting or rebuilding I-80 and because of the objections of the Air Force; it therefore is not proposed for consideration in the EIS (BLM 1985).

1.3.2.3 Counterclockwise Newfoundland Pond Alternative

The Counterclockwise Newfoundland Pond alternative (Fig. 4) is similar to the Bonneville Pond concept but does not inundate the Bonneville Speedway or Salt Flats (i.e., the West Pond shape is the same as that in the preferred alternative). Also, this option would involve slightly less flooding of Air Force land than the State's preferred option. However, this alternative has a considerably smaller evaporative area than does the State's preferred option. As is the case with the Bonneville pond, the return brine channel crosses Air Force land to the east of the Newfoundland Mountains.

1.3.2.4 Clockwise Newfoundland Pond Alternative

The Clockwise Newfoundland Pond alternative (Fig. 5) is of the same physical size as the Counterclockwise alternative, yet it utilizes less Air

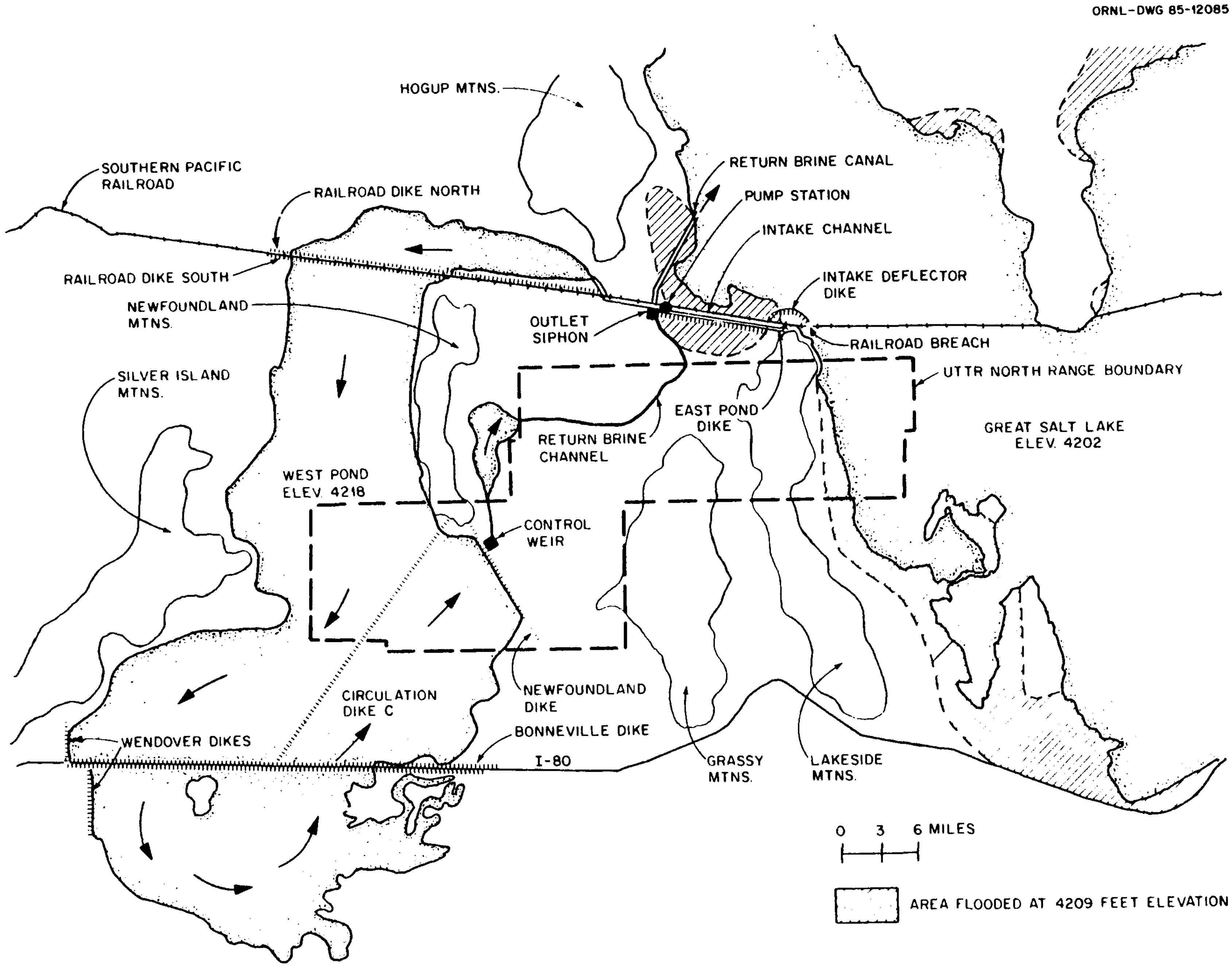

Figure 3. Map of proposed Wendover Pond option for implementing West Desert Pumping

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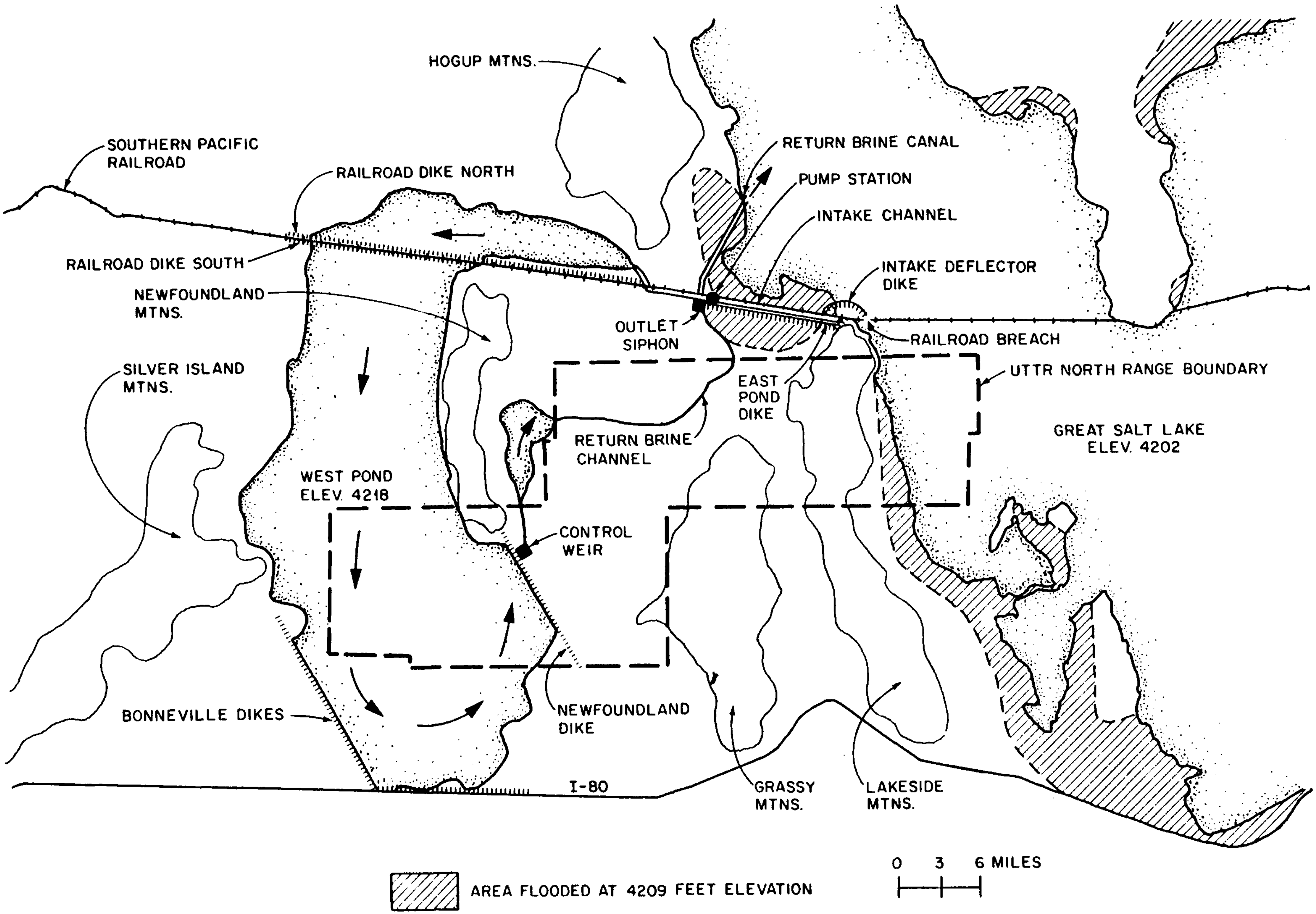

Figure 4. Map of proposed Counterclockwise Newfoundland Pond option for implementing West Desert Pumping

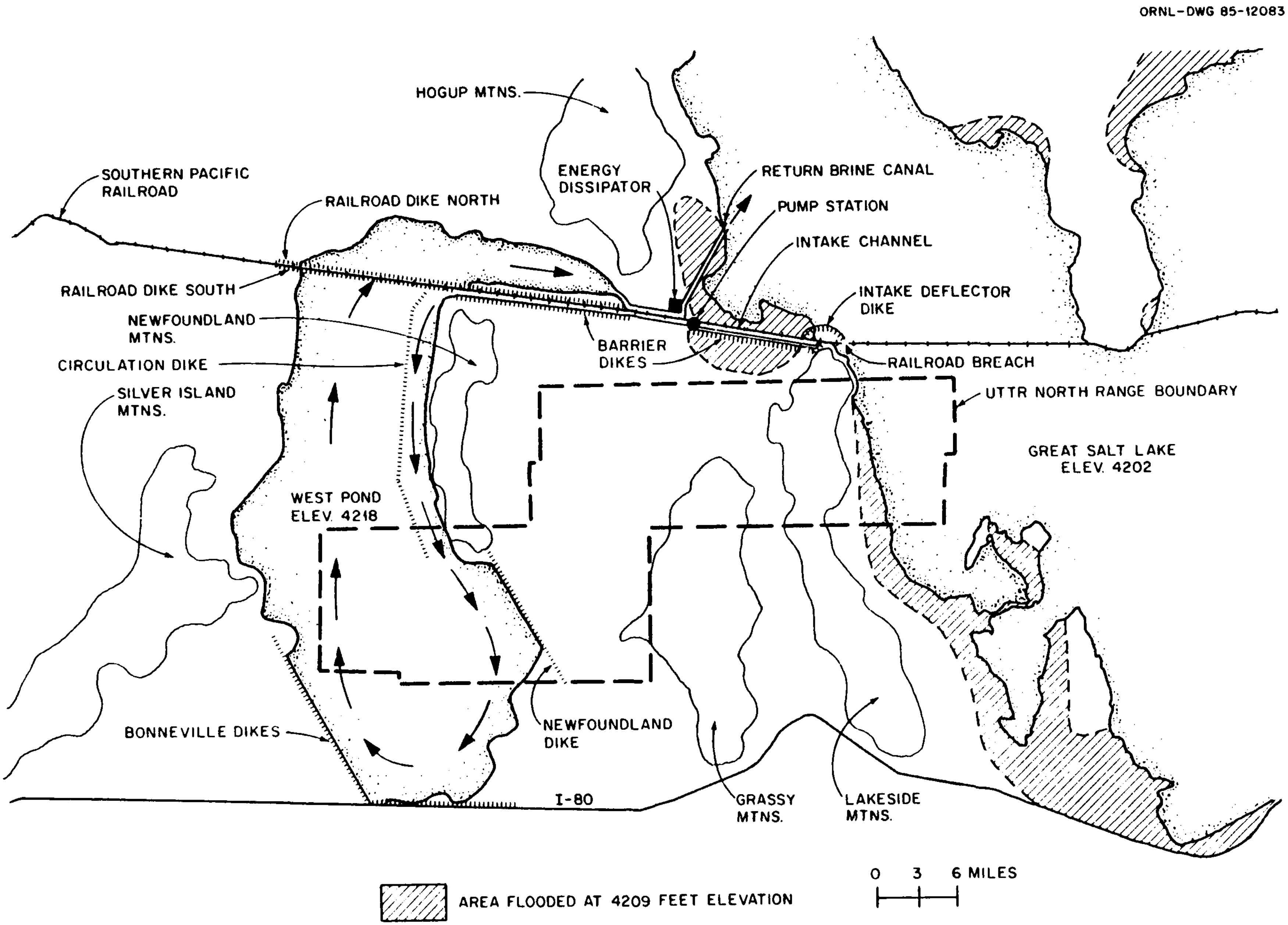

Figure 5. Map of proposed Clockwise Newfoundland Pond option for implementing West Desert Pumping

Force land than any of the previously discussed options (i.e., there is no East Pond or return brine canal in UTTR North Range property). It differs in two ways from the Counterclockwise alternative. First, the intake canal is extended westward along the south side of the railroad grade to the West Pond on the west side of the Newfoundland Mountain. This canal requires a barrier dike along its south side between the Hogup Ridge and Newfoundland Mountain. Second, the return brine is not routed through Air Force land in the East Pond area, but is circulated back to the Great Salt Lake through a channel cut in the Hogup Mountains north of the Southern Pacific Railroad. A flow direction dike is also required within the West Pond, extending southward from the SPRR track to beyond the southern end of the Newfoundland Mountains.

The clockwise flow pattern which routes the return brine to the lake without traversing Air Force lands east of the Newfoundlands is also applicable to the State's preferred option and the Wendover Pond and Bonneville Pond alternatives with only slight modifications. This alternative brine flow alignment creates a cutoff dam for storm water collection south of the Intake Canal Barrier Dikes and east of the Newfoundland Mountains. As a consequence, any seepage from the ponds and the natural drainage from the Newfoundland, Lakeside, and Grassy Mountains into this area would be trapped. To alleviate this condition, a storm water/seepage pump station would be required. This pump station could be routinely used to keep the entire area south of the Intake Canal essentially dry. Both Newfoundland Pond alternatives are proposed for consideration in the EIS (BLM 1985).

1.3.2.5 Northern Pond

Eliminating any flooding of Air Force land in the East Pond area would reduce any potential groundwater or surface water impacts to Air Force targets near the Lakeside Mountains. The state studies did not describe any West Desert pumping scenarios specifically designed to eliminate flooding of Air Force land in the East Pond area. One such scenario, termed the Northern Pond option, developed independently of the state studies consists of the following features that slightly modify the state's preferred option (Fig. 6):

1. A barrier dike extending westward from the Hogup Ridge to the Newfoundland Mountain east flank but located slightly north of the Air Force property boundary, thus forming an "East Pond," located north of the North Range, at 4214 ft.
2. A canal from the West Pond Control Weir extending along the east flank of the Newfoundland Mountains to the new "East Pond."
3. A canal from the new "East Pond" through the Hogup Ridge to the inverted siphon discharge facility.

The Northern Pond alternative has an evaporative area nearly equal to that of the State's preferred option, yet does not flood the North Range in the Lakeside Mountain area. It would protect the Air Force property east of the Newfoundland Mountains from flooding by the Great Salt Lake until the height of the barrier dikes was exceeded. The barrier dikes could be as high as the West Pond dikes or the proposed Great Salt Lake dikes (Sect. 1.3.3). As with the clockwise brine flow alignment discussed above (Sect. 1.3.2.4), a pump station would be required to remove water from the East Pond area that collects from natural runoff or seepage through the project

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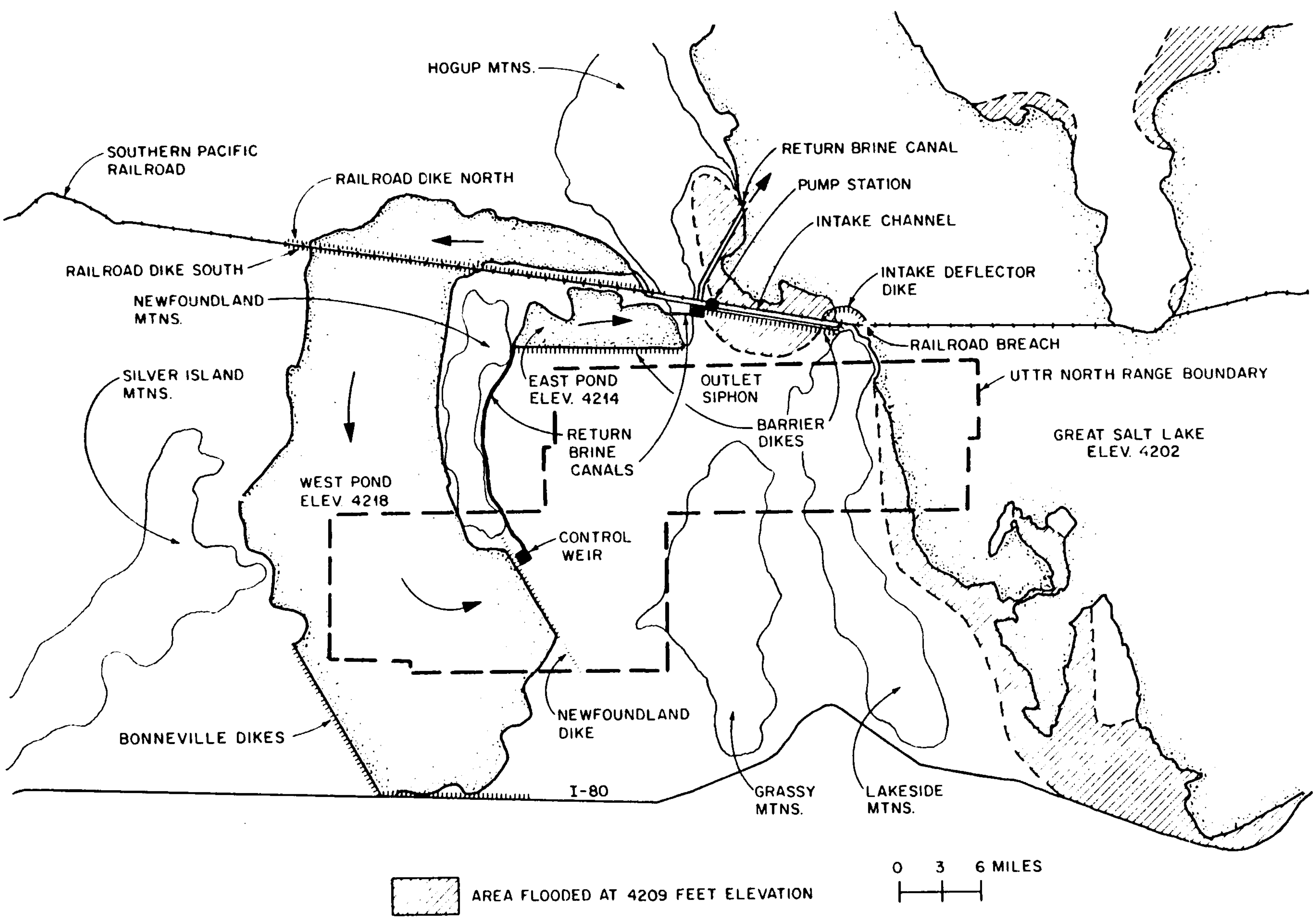

Figure 6. Map of Northern Pond option for implementing West Desert Pumping

dikes. Of all the options discussed above, the Northern Pond option would minimize the direct disturbance of Air Force land.

1.3.3 No-Action Alternative

The no-action alternative involves a decision to abandon the proposed West Desert Pumping project, probably in favor of proceeding with alternative flood protection (e.g., dikes) and other lake level management schemes [Sect. 1.3.4] (BLM 1985). As indicated in Sect. 1.3, the State has proposed and is proceeding with additional diking and associated facilities to protect, up to a lake level of 4212 ft and 4215 ft, critical public works and properties along the east and south shorelines of the lake. Diking to 4212 ft would occur concurrently and independent of the development of the West Desert Pumping project. Without the pumping project or other lake level management schemes, lake levels will rise faster and higher for those meteorological conditions that create greater lake inflows than losses (by evaporation). However, assuming that above-average rainfall continues, the State would need to prepare to raise the existing flood control dikes and expand the use of dikes into additional areas as other critical public and private facilities are threatened by rising lake levels.

If the annual high level of the Great Salt Lake were to exceed 4215 ft at least once [which has probabilities ranging from 0.0 to 0.01 in the period 1985 to 2030 (James 1984)], the lake would expand into the area between the Lakeside and Grassy Mountains on the east and Newfoundland Mountains on the west and would cause virtually the same impact in that area as those perceived for the State's preferred option. If the annual high lake level were to exceed 4217 ft, which has probabilities ranging from <0.001 to 0.01 in the period 1985 to 2030 (James 1984), the Great Salt Lake

would probably also flood most of the West Pond area of the State's preferred option and possibly the Bonneville Racetrack and Bonneville Salt Flats north and south of I-80. The Interstate highway may also be flooded at some points. Thus, the no-action alternative results in the possibility (which has a probability estimated at about 0.01), that Air Force land may be impacted by rising lake levels in the near future, if abnormally high precipitation rates continue in the future.

The Air Force could protect its property in the North Range of the UTTR from flooding by the Great Salt Lake, should the lake rise, by constructing dikes near Lakeside and along the railroad from Lakeside to the Hogup Ridge. However, in vew of the estimated remote changes of continued high rainfall and rising lake levels, the Air Force does not presently consider the construction as necessary. Since these dikes would prohibit the natural expansion of the Lake into an area that was historically available, thus increasing the flooding impact around the lake, an environmental analysis could conceivably be required, if this option were pursued by the Air Force.

1.3.4 Alternatives to West Desert Pumping

Methods of managing the level of Great Salt Lake or controlling flooding of its shoreline areas have included the following general concepts in addition to the proposed West Desert Pumping.

1. Diverting portions of the major river inflow.
2. Upriver storage of inflow from several river basins.
3. Diking in and around the lake to protect critical facilities, public property, and/or private interests.
4. Pumping to Puddle Valley for storage.
5. Combination of the above.

1.3.4.1 Diversion of River Inflow

The only diversion project that can significantly reduce the inflow to the Great Salt Lake involves the movement of Bear River water to the Snake River in Idaho via the Portneuf River. If this alternative were implemented, diversion of Bear River water to the Snake River could be undertaken for management of the lake level whenever excessive inflow is expected based on current rainfall and snowpack in the mountainous watershed and on predicted meteorological trends. This alternative offers the advantage of beneficial use of water in lieu of evaporation in the desert. The effectiveness of this alternative on lake levels depends on the capacity of the diversion project. Considering the lead-time (5-year minimum) for engineering and construction in the remote, mountainous region, the Bear River diversion concept is not considered to be a viable alternative to the proposed West Desert Pumping project to mitigate the immediate problems associated with the existing elevation and near-term rising level scenario of the Great Salt Lake. However, based on the low precipitation levels received during the 1984-1985 water year in the Great Salt Lake area, the urgency for implementing near-term options is lessened. If below normal precipitation continues, ample time should be available to pursue and implement viable longer time options. If the diversion could be initiated in the early years of a period of rising lake levels, it should markedly reduce the need for implementing any West Desert pumping options, and would reduce the duration of operation of the West Desert Pumping project, if implemented. Thus, the Air Force strongly supports the studies of Bear River diversion feasibility.

There are some flood control and small diversion projects planned or underway for the Weber, Provo, or Jordan Rivers. The capacity of these projects could possibly be expanded with greater emphasis on diversion into another storage basin, e.g., the dry Sevier Lake bed via the Sevier River. This would offer the advantage of beneficial use of water instead of evaporation in the desert. The potential annual volume of inflows to the Great Salt Lake from the three rivers that could be diverted would have a significant effect on the level of the Great Salt Lake during a period of normal inflow. However, the effect on the lake level during an abnormal period such as 1983 and 1984 would not be great. Historical trends of the lake level suggest that a recurrence of the 1983-1984 inflow in the near future should be extremely rare. Therefore, these small diversion projects incrementally may be viable alternatives in part to the West Desert Pumping project, when considered separately or in conjunction with other viable alternatives. The Air Force supports continued feasibility studies because these projects have the potential to reduce the need for and use of the West Desert Pumping project for lake level management.

Another option that was mentioned during the EIS scoping process is the "Fresh Way" alternative, in which water from the Bear River is sent via aqueduct directly to the West Desert, where it could then be used for irrigation.

1.3.4.2 Upriver Storage

Upriver storage of freshwater runoff via the drainage systems that feed the Great Salt Lake (Bear, Weber, Provo, and Jordan Rivers) have long been considered in conjunction with irrigation development for regional agricultural growth. The use of upriver storage as a means of controlling

the rate of rise of the lake level has been studied recently by the State. The results indicate that 300,000-400,000 acre-feet of storage is currently available which could be developed in the Bear River watershed. This figure is limited to conform to the permitted annual withdrawals allowed by the Idaho/Utah water pact. Development beyond this level would involve considerable legal (water rights) and political problems. The viability of expanded upriver storage is dependent on changing the Idaho-Utah water use pact, which would allow Utah to increase annual use of water for irrigation beyond the current level of 300,000 to 400,000 acre feet of storage. Based on current lake area, this volume could reduce the lake level rise in a given year by only 3.5 inches if only 300,000 to 400,000 acre feet of storage were developed, which is much less than the effectiveness of the West Desert Pumping project. Upriver storage in the three other drainage systems would probably not amount to more than half of the potential capability in the Bear River drainage area. Upriver storage, if developed, would provide beneficial water use that satisfies a growing demand of freshwater for agricultural development, would not create much area for evaporation and would not be available for year-to-year management of Great Salt Lake levels unless equivalent water consumption projects, such as widespread agricultural uses, were developed very quickly. Finally, these water storage projects may require up to a decade to develop and are expected to be much more expensive than the West Desert Pumping project, however, each would present a greater beneficial water use. In summary, upriver storage is not a viable alternative to the proposed West Desert Pumping project in the near term. However, based on the below normal precipitation received in water year 1984-1985, the urgency for implementing

near term options may be reduced. If 1984-1985 precipitation levels continue, ample time should be available to develop and implement long term options. The water use rights would need to be renegotiated with Idaho for upriver storage to become a viable, economically attractive, alternative. The concept, which is supported by the Air Force, could be developed to assist with long-term management of the level of the Great Salt Lake.

1.3.4.3 Diking of Great Salt Lake

Diking along the shoreline of the Great Salt Lake to protect critical facilities, public property, and private residential, commercial, and industrial interests can be accomplished as a direct alternative to the West Desert Pumping project. The State has previously constructed many dikes, particularly to protect the wildlife management areas in the freshwater floodplains of the Bear and Weber Rivers. Most of these dikes have already been topped by the rising lake level. The State has also sponsored continuing feasibility and cost studies to assist in defining the optimum cost-effective approach to protect the eastern and southern shoreline environment and facilities that are currently being threatened by the rising lake level.

The most recent study (Montgomery 1984) identified a range of diking alternatives that include:

1. Protection only for critical public facilities such as municipal waste water treatment plants, highways, and the Salt Lake City International Airport.
2. Protection of major segments of the shoreline environment, e.g., within Farmington Bay, Ogden Bay, or Bear River Bay/Willard Bay regions.

3. Protection of the total South Arm shoreline from the Lakeside Mountain at the southwest corner of the lake to Promontory Point, thus encompassing public, residential, commercial, and industrial interests.

This study included engineering concepts, feasibility, and cost estimates for shoreline protection at lake elevations of 4212 and 4217.

Detailed planning and construction for the dike protection of critical public facilities up to 4212 ft is already underway and more has recently been approved. However, these diking projects do not include protection for the wildlife management areas in Farmington Bay, Ogden Bay, Bear River Bay, or Willard Bay, nor the industrial mineral (salt) recovery facilities, which have already been seriously impacted. If the lake rises above the 4212 ft elevation (an event which has a probability of occurrence of less than 15% by the year 2050), the facility-specific dikes could be readily raised (e.g., 4215, 4217 ft), and additional site-specific dikes could be constructed if other public facilities are threatened by the rising water level.

Diking of all or major portions of the developed shoreline and wildlife management areas for protection at the 4212 ft elevation would be difficult in the short term because of the engineering, logistics, and legal complexities. However, if future precipitation levels are similar to those of the 1984-1985 season or are close to the historic average levels, ample time should be available to the State to solve the engineering, logistics and legal complexities. The Air Force believes that the State should proceed immediately with the most likely long-term diking projects for the 4212 ft and/or 4215 ft protection criteria to provide a measure of flood

protection and to become the base for a possible future need of flood protection dikes for higher lake levels, if required. Again, as noted earlier, if the lake elevation were to reach 4215 or 4217 ft, the lake would likely expand onto the Air Force land. However, the probability of the lake reaching 4215 ft is remote, and the likelihood of the lake exceeding 4215 ft is about 0.01 (before the year 2030), and the probability of the lake level reaching 4217 ft is practically zero. Nevertheless, if the lake were to rise in this fashion, the water would likely be present longer on Air Force land under a lake level management scheme than it would be under natural flooding.

1.3.4.4 Pumping to Puddle Valley

The Puddle Valley alternative involves either pumping water from the Great Salt Lake to Puddle Valley with no return or a pump storage project where water is stored in Puddle Valley and then returned to the lake to generate electrical power. Puddle Valley is located between the Grassy and Lakeside Mountains west of the Great Salt Lake. The principal advantage of the project is a beneficial use of Great Salt Lake water (i.e., power generation). Primary disadvantages are the long conduits required to get the water from the lake to Puddle Valley, and a relatively low head. Also, infiltration from an artificial brine like in Puddle Valley could disrupt the present groundwater regime in and around the valley, thus causing wells around the valley to become saline. Lastly, although the project was found in an initial investigation to be economically feasible, the electric utilities in the area have shown no interest in the project.

1.3.4.5 Combinations

Combinations of one or more of the above West Desert pumping options should be explored in greater detail to ascertain their usefulness in controlling the lake level without flooding the West Desert area. It is possible that the advantages of one option may outweigh the disadvantages of others, such that a combination of alternatives could achieve lake level control goals without West Desert pumping.

2. EXISTING ENVIRONMENT

This section describes the UTTR and vicinity to provide a framework for assessing potential impacts. Physical attributes relevant to key potential impacts (meteorology, groundwater and others) are described, followed by a brief discussion of existing operations at the UTTR.

2.1 PHYSICAL FEATURES

The UTTR is comprised of over 1,500,000 acres (1,800 square nautical miles) of Department of Defense (DOD) land, 4,283 square nautical miles of restricted airspace and 10,965 square nautical miles of military operating areas. Over 7,000,000 acres (8,200 square nautical miles) of BLM and State land is available for overflight.

DOD withdrawn land within the UTTR is composed of separate Air Force-owned and Army-owned lands, most of which is managed by Air Force Systems Command. The Air Force-owned lands consist of the Hill Air Force Range, located north of Interstate I-80 (referred to as the North Range) and the Air Force Wendover Range to the south of I-80. Army-owned land comprises the Dugway Proving Ground (DPG), which is managed by the Army. The Wendover Range and DPG are referred to as the South Range (Fig. 7).

2.1.1 Topography

A varied topography is found in the vicinity of the Great Salt Lake (Fig. 8). The North Range consists mostly of marly mud flat areas that surround north-south mountain ranges. The mud flats are almost level; topographic relief is on the order of 4 to 5 ft within the 12 to 20 mile wide mud flat area (Dames and Moore 1985). To the east of the mud flats are sand dunes that rise 10-20 ft above the mud flats within a distance of several hundred feet. Additional mud flats occur farther east of the sand

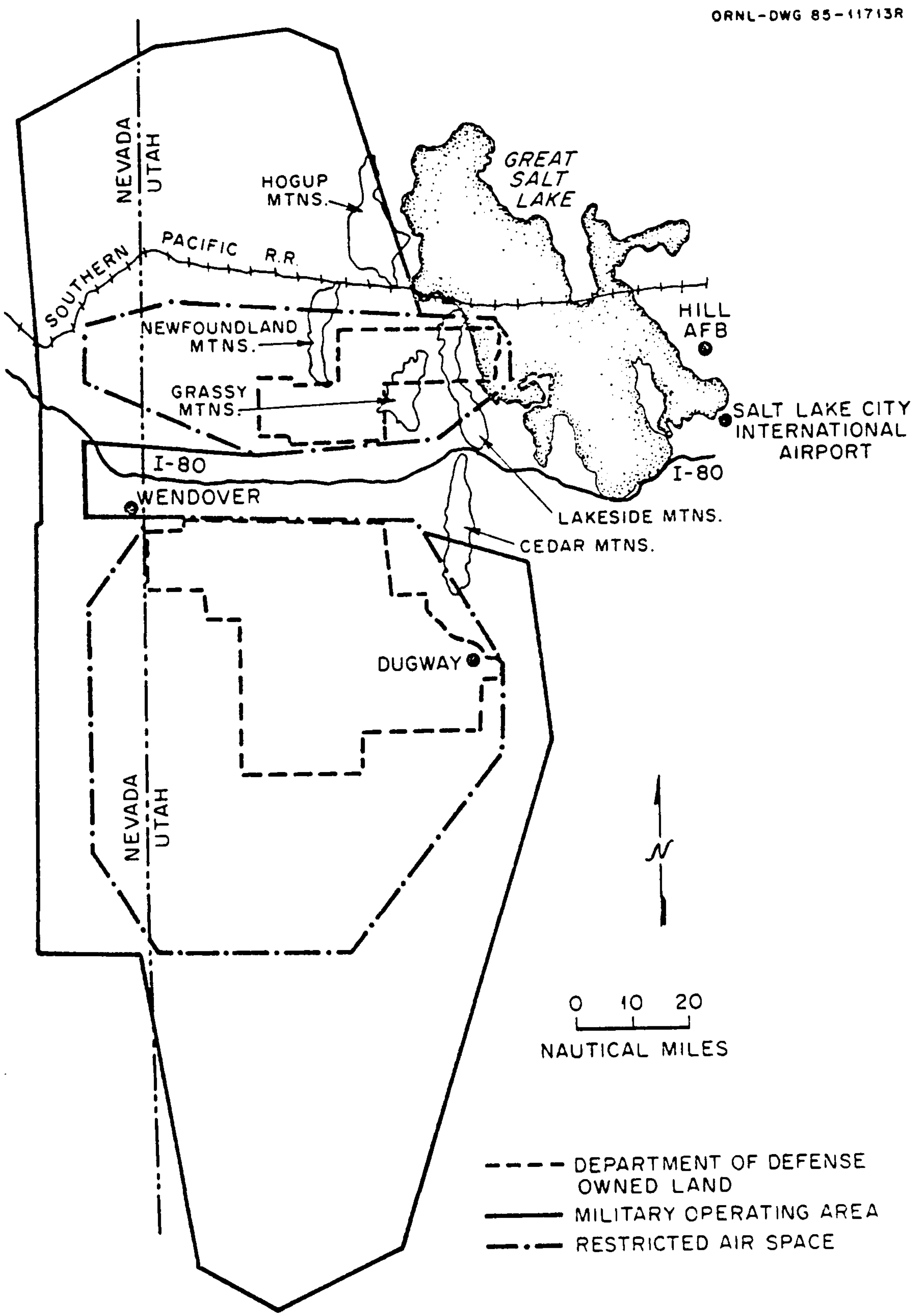

Figure 7. Location map for Utah Test and Training Range (UTTR)

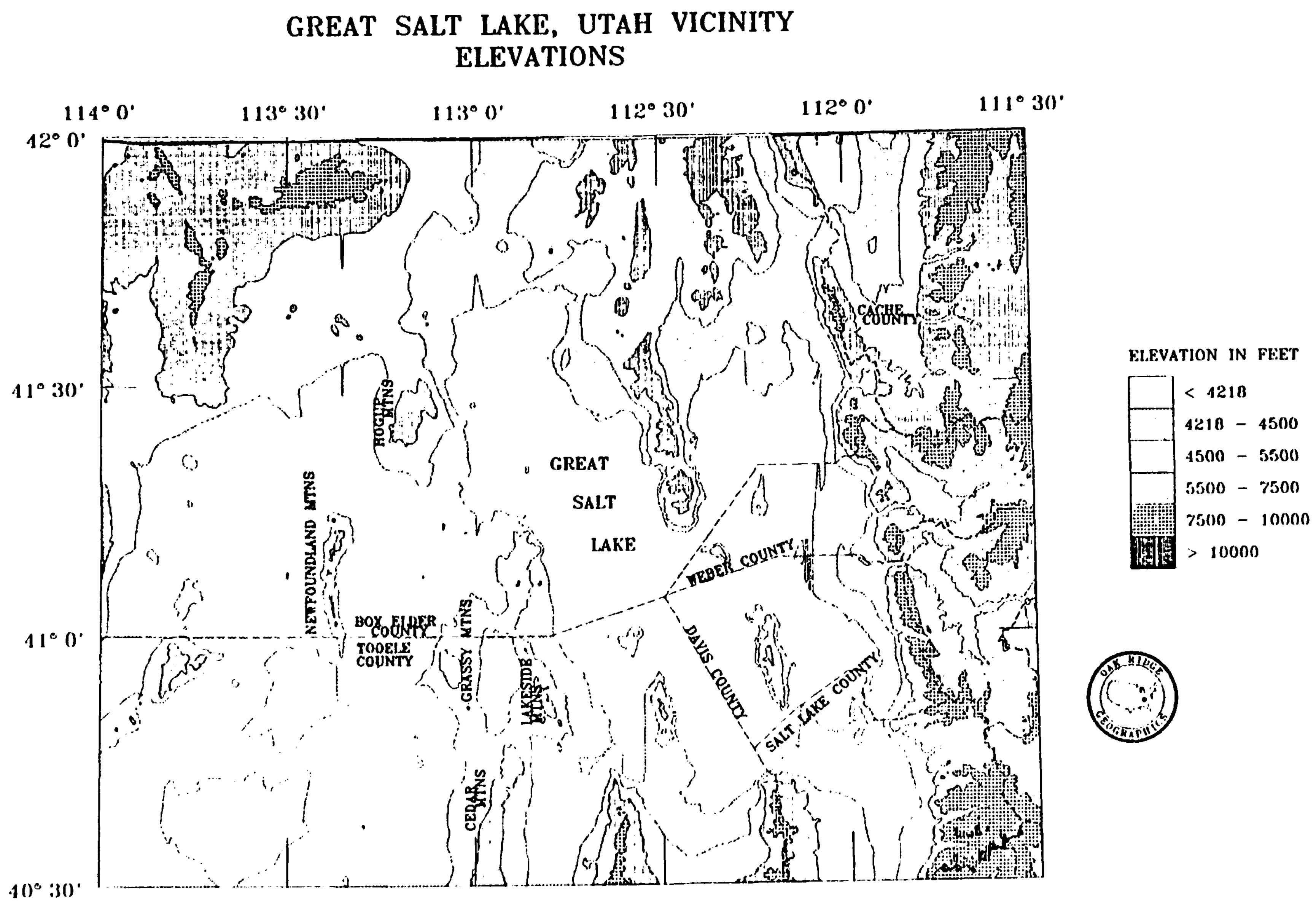

Figure 8. Elevations in the Great Salt Lake vicinity

dunes; they tend to be lower in elevation than the dunes themselves, but about 5 to 8 ft higher than the main mud flat areas. North-south mountain ranges rise abruptly above the mud flats, with maximum elevations on the order to 5,000 to 6,500 ft (Dames and Moore 1985). The South Range exhibits a similar variability in topography, with low-lying mud flat areas surrounded by mountains. Mountains on the South Range tend to be slightly higher, with elevations ranging from about 5,000 to 9,000 ft. This wide topographic relief allows weapons testing and training to occur at targets located in a variety of topographic situations.

2.1.2 Meteorology

Meteorological conditions at the UTTR generally represent arid conditions. In the West Desert, precipitation averages less than 6 inches/yr (Ruffner 1978). At Wendover, which is located in the northern part of the South Range, annual precipitation has ranged from a low of 1.77 inches in 1926 to a high of 10.13 inches in 1941 (Dames and Moore 1985). Precipitation is distributed throughout the year, but the spring months are the wettest. On the eastern side of the Great Salt Lake, precipitation levels are higher. Long-term (past 110 yrs) precipitation levels at Salt Lake City International Airport average about 15 inches. Temperatures range from a low of about 0°F to a high of around 100-105°F. The mean annual wind speed in the UTTR vicinity is about 4 mph; wind speeds are greatest during the spring and summer months, when gusts associated with thunderstorms exceed 50 mph (Ruffner 1978).

Weather conditions play an important role in the performance of test and training activities on the UTTR. The various range users (see Section 2.2) have identified key weather parameters and minimal values for these parameters under which they can conduct their activities. Key parameters of

interest to the range users are generally the horizontal visibility and the height of the cloud cover. The minimal values of these parameters under which the range users can operate can differ among users, however. The most frequently used values are a 3,000 ft ceiling and 3 mile horizontal visibility, usually referred to as "3000/3" conditions. In other words, scheduled missions are cancelled if the ceiling is less than 3,000 ft <u>or</u> if the visibility is less than three miles. These are not the most stringent weather conditions, merely the most frequently used. For example, cruise missile testing operations demand clear conditions up to an altitude of about 30,000 ft MSL. Conditions less than 3000/3 are most likely to be experienced in the winter quarter (December-February). In the North Range, conditions less than 3000/3 are met about 14% of the time in these months (based on data collected at Eagle Range). Similar patterns are observed for the South Range. In the summer months (June-August) throughout the UTTR conditions below 3000/3 occur less than 1% of the time. Weather conditions force a greater number of mission cancellations in the winter throughout the UTTR.

2.1.3 Hydrology

The UTTR hydrology is influenced by water inflow from precipitation and runoff and outflow from evaporation and groundwater recharge. Water can also enter the UTTR North Range (if the Great Salt Lake elevation exceeds the 4215 ft threshold, an event which has an approximate probability of 0.01 between 1985 and 2030) by passage between the Hogup and Lakeside Mountain (or Grassy Mountain) Ranges. Runoff is less significant than direct precipitation in the mud flat areas. Computed annual average surface runoff from the highest mountains averages less than one inch, which is only about 15% of the amount contributed by precipitation (Dames and Moore 1985).

Runoff from snow melt usually peaks in April, May or early June (Ruffner 1978). Precipitation in the mountainous areas of the UTTR generally runs off into the relatively coarse alluvial material located downslope of the bedrock, and recharges groundwater in the transition areas between mountains and mud flats. Precipitation falling on the mud flats is temporarily stored as soil moisture and is removed through evaporation (Dames and Moore 1985).

Surface water on the UTTR is seasonal. Satellite imagery data (LANDSAT) collected during April, 1984, when the lake level was about 4208 ft (Christensen 1985), show standing surface water and/or wet areas in the North Range (west of the Hogup Mountains and surrounding the Newfoundland Mountains) and in the northwest corner of the South Range in the area of the Bonneville Salt Flats. The wet areas, which are primarily mud flats, result from a variety of factors, direct precipitation onto the area, saturated soil (i.e., minimal groundwater recharge), reduced evaporation and, to some extent, mountain runoff. Satellite data for July and August of the same year, when precipitation was reduced from April levels and when evaporation was higher, illustrate that the surface water area in the North and South Ranges had decreased considerably (NOAA 1985). Existing surface water drainage problems in most of the target areas in the North Range are due primarily to water trapped on the surface by zones of caliche ranging from a few inches to over a foot thick, and generally occurring near the groundwater surface (Dames and Moore 1985).

Groundwater in the UTTR has been recently characterized in a special study conducted by Dames and Moore (1985) for the State of Utah. According to the results of this study, groundwater in the flat lake bed areas is within 1 ft of the ground surface and gradients are on the order of 1 ft/mile. In the higher sand dune areas located to the east side of the

North Range, groundwater is anywhere from 6 to 17 ft below various targets, and the gradients are on the order of 10 ft/mile (Dames and Moore 1985). Earlier studies indicate that the groundwater is highly saline; in the North Range, measured groundwater quality (dissolved solids) has been found to vary from >35,000 mg/L in the mud flat areas to about 10,000-35,000 mg/L in the higher elevation areas on the east side of the range (Stephens 1974).

2.1.4 Land Use

Current land use in the UTTR is dominated by Department of Defense (DOD) activities principally associated with the U.S. Army and the U.S. Air Force (Sect. 2.2). Air Force activities involving weapons testing are confined to land owned by the DOD. Personnel training in aircraft involves overflight of areas not owned by DOD. Land use in these areas currently consists mostly of grazing. Small, isolated mining and agricultural operations are also found in areas located under airspace in the north and south ranges.

2.2 PRESENT OPERATIONS

The mission of the UTTR is to provide a broad range- and test-support base to all Department of Defense (DOD) components responsible for development, testing, evaluation and training. Support is provided for development, test and evaluation of manned and unmanned aircraft systems, air-to-air and air-to-ground training of Air Force (and other government agency) personnel, and initial operational testing and evaluation of selected programs. Major commands using the UTTR are Air Force Systems Command (AFSC), Air Force Logistics Command (AFLC), Strategic Air Command (SAC), Tactical Air Command (TAC) and Air Force Reserve (AFRES). For the purposes of this report, AFRES is usually referred to as a TAC-gained or

TAC-affiliated unit because TAC and AFRES training programs are very similar.

General locations of existing and planned test and training activity areas in the UTTR north and south ranges are shown in Fig. 9. The following existing activity areas are identified by number in the figure:

1. Helicopter Air-to-Ground Area
2. Eagle Air-to-Ground Bombing and Strafing Range
3. Munitions Test Targets
4. Remote Piloted Vehicle (RPV) Launch Area
5. Air Combat Maneuvering Instrumentation Area
6. Baker's Strongpoint Target Complex
7. U.S. Army Dugway Proving Ground Test Area
8. Ground Launched Cruise Missile Launch Area and Cruise Missile Recovery Area
9. Wildcat/Kitty Cat Target Complex
10. New Tactical Target

The following are brief descriptions of activity areas of key interest.

The Helicopter Air-to-Ground (HAG) Tactical Range is an unmanned air-to-ground range located in the North Range. The range is located between the Lakeside Mountains and the Great Salt Lake's western shore. Range elevation varies from 4200 ft MSL to 5855 ft MSL. Training ordnance is permitted, whereas heavy-case inert bombs are prohibited.

Eagle Range is a scorable air-to-ground gunnery and bombing range located in the North Range. The range, located at the northwest corner of Grassy Mountain, consists of two bomb circles, four strafe targets, two rectangular skip targets and two applied tactics targets. Elevations of the Eagle Range components vary from 4,227 ft to 4,246 ft.

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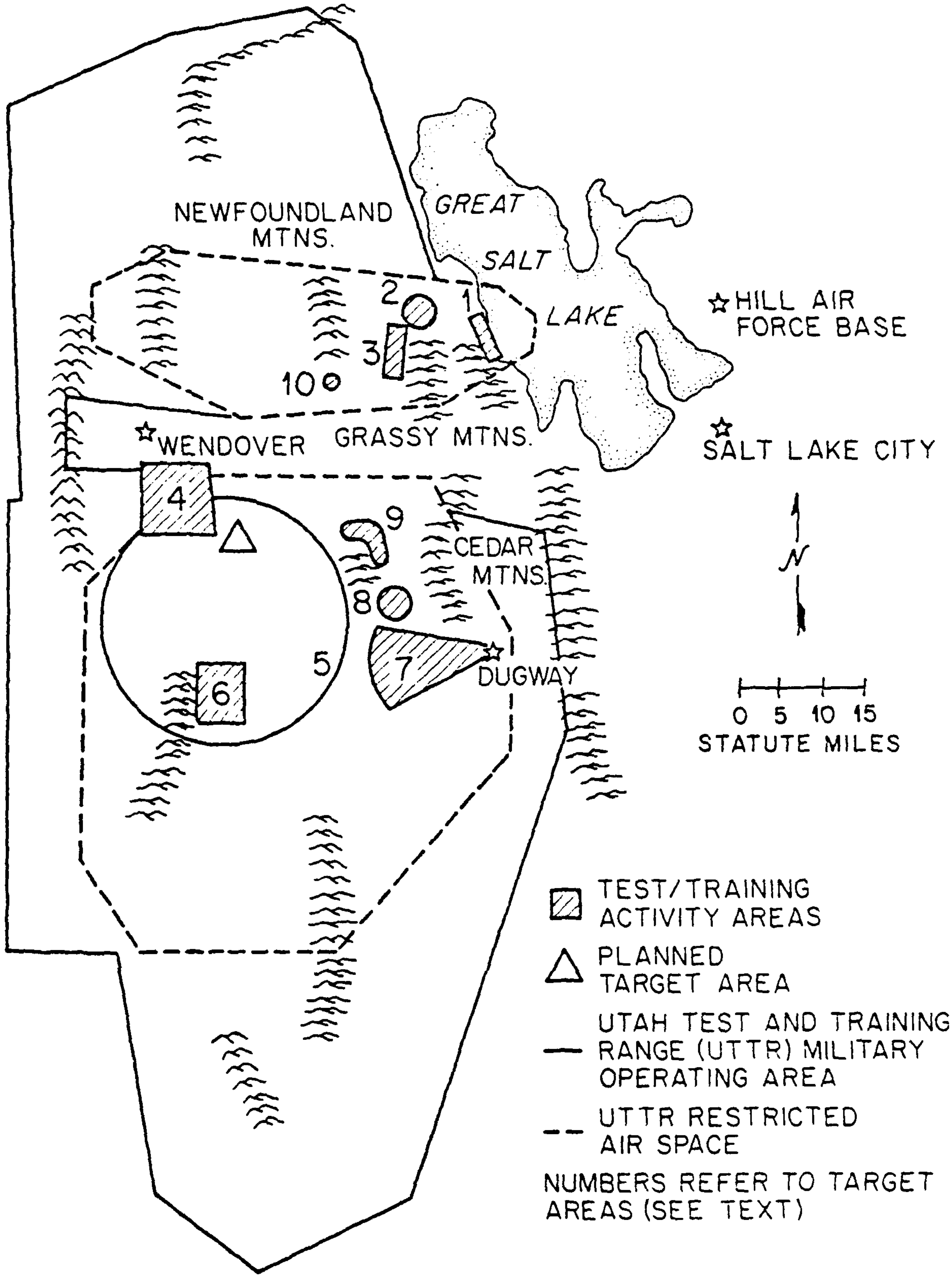


Figure 9. Locations of test and training activity areas in the Utah Test and Training Range (UTTR)

The Munitions Test Targets, which were developed by the U.S. Air Force Logistics Command to support their munitions test program, are generally located in the eastern portion of the North Range. Each target has been developed for specific applications, which include inert and live munitions, flares, fire bombs and cluster bomb units (a bomb which releases many smaller bombs upon opening in flight). A number of targets are considered inactive, although they can be reactivated if the requirement exists (Sect. 3.2.1). The FY 1985 value of the munitions inventory tested is about $930 million for the UTTR targets (shelf life and life cycle testing only).

The Remote Piloted Vehicle (RPV) Launch Area, located in the northwest corner of the South Range, is used for the launching, flight and recovery of remotely controlled small aircraft (drones). The center of the area is located at 40°30' N, 113°45' W.

Air-to-air gunnery training against towed targets (darts) is conducted to the east of the RPV Launch Area (Area 4) in the northern part of the South Range (Air Combat Maneuvering Area). The dart training is conducted at a minimum altitude of 5,000 ft Above Ground Level (AGL).

Wildcat Range is a multiple target complex located east and north of Wildcat Mountain in the South Range. The complex simulates an airfield with support facilities and area defenses. Elevations of targets in the Wildcat Range vary from 4257 ft to 4585 ft.

Kitty Cat Range, in the South Range, is located on the southeast side of Kitty Cat Mountain, 3 miles northwest of Wildcat Mountain. The range contains a single target area consisting of three tracked vehicles with mounted guns to resemble an artillery fire support base. Only conventional deliveries of live ordnance with impact fusing are authorized.

Baker's Strongpoint tactical target complex is located in the South Range, south of Goodyear Road near the South Range western boundary. Simulating a fortified desert position, the target is an earthen revetted area about 330 ft long and enclosed by a wall about 15 ft tall. Within the area are several revetted artillery positions used for interdiction training. Deliveries of inert rockets, heavy-case bombs and strafe munitions are conducted.

Cruise missile testing is conducted by a variety of Department of Defense organizations on the UTTR. The cruise missile launch/termination area is located in the South Range near Dugway. In general, cruise missile flights use the military operating areas in both the North and South Ranges. The testing operations involve the missile itself plus a contingent of support aircraft for following the missile in flight. Because of the airspace requirements of the missile tests, other range activities are not conducted or are severely curtailed during cruise missile testing. Although a variety of Department of Defense organizations are involved in cruise missile testing at the UTTR, this report will focus on those cruise missile test activities conducted by the SAC. Impacts to other cruise missile testing activities are assumed to be similar to those anticipated for SAC.

Hill Air Force Base (AFB), located on the east side of the Great Salt Lake to the south of Ogden, Utah, serves as the command base for UTTR operations. Most of the facilities, personnel and equipment needed to support the UTTR mission are based at Hill AFB. However, users of the UTTR are not restricted to Hill AFB. For example, TAC units from Mountain Home AFB in Idaho are regular users of the UTTR.

The physical characteristics and location of the UTTR make it unique for its mission. It is centrally located with respect to several other

major training ranges in the western United States, making it a vital link for training of Air Force, Navy and Marine air units. A microwave data and communications link from the west coast ranges (Western Space and Missile Center and Pacific Missile Test Center) to the UTTR through the Air Force Flight Test Center at Edwards AFB (California), and the Naval Weapons Center at China Lake (California), make it possible to conduct large scale exercises, such as cruise missile tests, that can feasibly be controlled from any of these control centers. The remote location and lack of physical access into the range make the UTTR relatively free from outside surface monitoring of microwave transmissions, which is desirable for Air Force operations and which is difficult to achieve at other U.S. Ranges. The population centers along the Wasatch Front are separated from the UTTR by mountain ranges, thus minimizing encroachment of range boundaries due to public or commercial enterprises. Thus, potential problems from noise impacts or electromagnetic interference to populated areas are almost non-existent. The terrain of the UTTR makes it ideal for low-level, terrain-following flight test and training exercises, such as those conducted by TAC and SAC. For example, the UTTR is the only range in the United States that has sufficient airspace and the variations in ground terrain (Fig. 8) to support programs such as cruise missile test and training, which are vital to national security. The physical size, varying topography, role as a major munitions test facility and remote location make the UTTR a unique national asset in which to test and evaluate training and operational concepts in a variety of arenas.

Because of its many attributes, the UTTR is heavily used by the Department of Defense. From 1979-1982, the total number of sorties for the entire UTTR (North and South Ranges) increased from about 14,000 to about

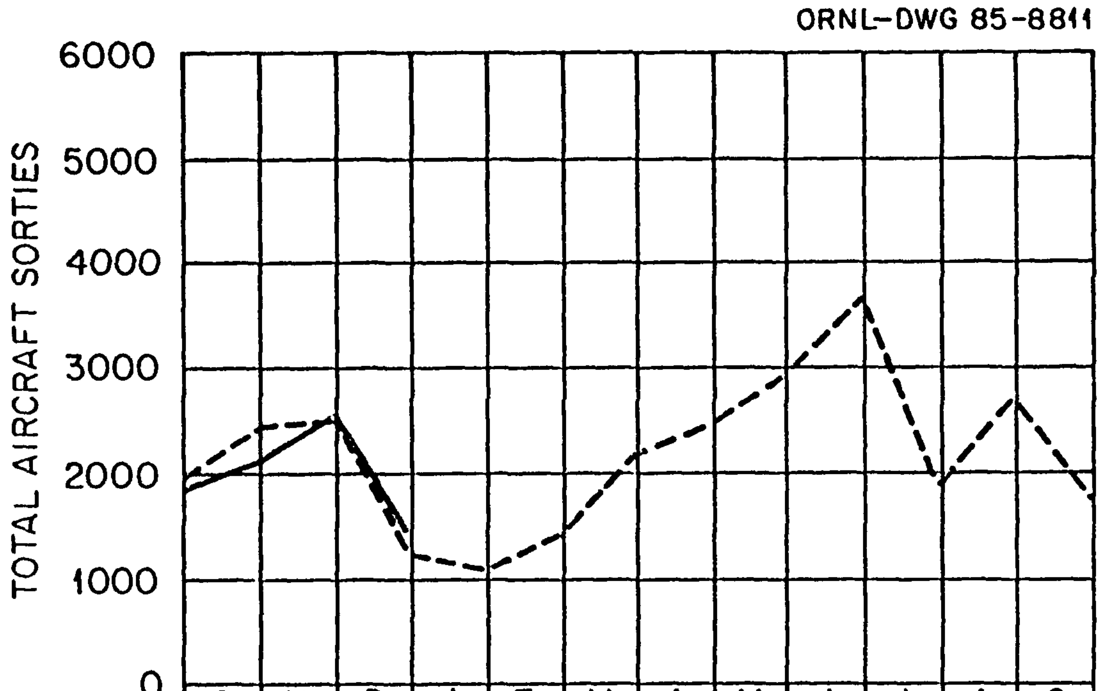
27,000. As shown in Fig. 10, annual use of the UTTR in Fiscal Year (FY) 1984 varied from a low of about 1,100 sorties in January to a high of about 3,700 sorties in June; this pattern reflects the trend in UTTR meteorological conditions discussed in the previous section. Use of the North Range, which would lose the most land space to ponds, has increased from about 10,900 sorties in 1982 to about 11,600 sorties in 1984. Cruise missile testing activity, which uses both the North Range and the South Range, is currently (FY 1985) conducted at a level of about 47 tests/yr (including air-, ground-, and sea-launched cruise missile tests using the UTTR for either launching/termination or for termination only).

While the AFLC owns the UTTR, the U.S. Air Force Systems Command (AFSC) manages the UTTR, and therefore is responsible for scheduling sorties into the North and South Ranges in support of other MAJCOM programs [principally those of AFLC, Strategic Air Command (SAC), and Tactical Air Command (TAC)]. Table 1 summarizes the number of sorties operated during FY 1984 for the North and South Ranges. TAC is typically the heaviest user of the North Range; in FY 1984, over 80% of the North Range sorties were accomplished by TAC. A priority system is used for scheduling range time. The approximate priority for range use is cruise missile testing > munitions testing > pilot training/weapons testing.

More detail on the UTTR operations is provided as appropriate in the discussion of potential impacts to operations (Sect. 3).

2.3 FUTURE OPERATIONS

Future uses of the UTTR can be described in terms of those actions initiated by the U.S. Air Force and those initiated by other DOD agencies.



		O	N	D	J	F	M	A	M	J	J	A	S
1984	- - -	2313	2406	1322	1097	1418	2168	2403	2972	3607	1883	2764	1894
1985	——	2164	2418	1490									

Figure 10. Total aircraft sorties in UTTR, FY 1984 and first quarter, FY 1985

Table 1. Utilization of the UTTR in Fiscal Year 1984 (ending September 30, 1984).

	North Range	South Range[a]	Total
Logistics Command (AFLC) Test Sorties	1,094	445	1,539
Strategic Air Command (SAC) Exercises and Training	b	342	342
Tactical Air Command (TAC) Exercises and Training[c]	9,359	12,773	22,132
Other[d]	1,135	1,099	2,234
Total	11,588	14,659	26,247

[a]Obtained by deducting North Range missions from total UTTR missions.
[b]SAC missions may also overfly a portion of the North Range.
[c]Includes Air Force Reserve units.
[d]Includes missions by units from other military services.

TAC is studying the use of UTTR for an Air-to-Ground Weapons System Evaluation Program (AG/WSEP) that will be used to evaluate the performance of present and future precision-guided munitions in a realistic operational environment. Plans call for the use and installation of precision tracking equipment and telemetry to enable analysts to monitor key aspects of weapon performance. AG/WSEP will begin in CY 1986 and build in the long term up to 400 sorties annually. USAF Headquarters is considering the UTTR for a large electronic combat test range. The UTTR is the only test and training range in the continental United States with the necessary land, airspace and geographic features to accommodate an extensive electronic combat test and training complex. Cruise missile testing, which is currently done at a level of about 47 tests/yr (FY 1985) is expected to increase to a maximum of about 73 tests/yr in FY 1987, and then decrease to about 56 tests/yr over the period 1991-1999. As illustrated in Fig. 8, one new target is planned

for the UTTR -- it will be located in the north part of the South Range to the east of the Remote Piloted Vehicle Area (#4). The one planned target reflects the fact that all of the usable target sites at the UTTR have already been utilized. Thus, increases in UTTR use will likely be accomplished primarily by increasing the use of existing targets, rather than constructing new ones. Existing non-scorable targets on the UTTR may be upgraded with scoring capabilities to improve training exercises. Other planned changes at the UTTR, as contained in the UTTR Range Program Plan (December 1984), involve primarily changes to air space.

Future operations at the UTTR are also planned by other DOD agencies. Increasing levels of U.S. Army testing over the South Range have forced the scheduling of more tactical missions over the North Range. If current trends continue, the use of existing North Range targets could thus increase.

3. IMPACTS

This section discusses potential impacts of the West Desert Pumping Proposal (the State of Utah's preferred option for Great Salt Lake water level management) on the UTTR. As discussed in Sect. 1, although other long-term opt ns exist for controlling the lake level, none of those discussed are anticipated to have significant adverse impacts on the UTTR. Rather, their principal impact to the UTTR would be positive in that they would obviate, for the most part, the need for using West Desert Pumping, to control the lake level.

Most of the discussions in this section are based on the State's preferred option for implementing West Desert Pumping which consists of an East Pond and a West Pond (Sect. 1.3). The key environmental impacts (meteorology, hydrology, etc.) of the proposal are discussed first, followed by an analysis of potential impacts on present and future UTTR operations.

3.1 ENVIRONMENTAL IMPACTS

Although a variety of potential environmental impact areas will be addressed in the EIS (e.g., water quality, socioeconomics, cultural resources, ecology, etc.), this section will focus on meteorology and hydrology (groundwater and surface water), and land use which are expected to represent the principal impact areas to Air Force facilities and operations.

3.1.1 Meteorology

Because of a lack of unbiased historical meteorological data for the UTTR, the weather impacts of the proposed ponds can best be estimated by using locations upwind and downwind of the Great Salt Lake for which adequate data are available. After screening various data sets in the UTTR

and vicinity, it was decided to use weather data collected at Dugway, which is in the South Range, as a surrogate for the North Range before the ponds, and data collected at Salt Lake City (SLC) International Airport as a surrogate for the North Range after the ponds. In other words, the Great Salt Lake is serving as a surrogate for the proposed ponds. The analysis focuses on the North Range because its weather would be more affected by the proposed ponds than weather in the South Range. Within the North Range, a series of targets located along the western side of the Grassy Mountains (Fig. 8) is of particular interest. It will be assumed that the changes in weather conditions predicted for the North Range would also occur in the northern 5 km of the South Range. Although there is likely to be a diminishing of weather impacts with increasing distance from the ponds' shorelines, presently available data sources and methods of analysis do not allow quantification of the gradient. Appendix A presents more detail on the data, methods of analysis and rationale for the study of weather effects of the proposed ponds.

Based on the analogy between Dugway weather as pre-pond (existing) North Range conditions and SLC weather as post-pond North Range conditions (with East and West Ponds), the number of hours for restricting flights over the North Range will be increased. Based on historical (late 1949-1970) meteorological data, the total number of restricted hours will rise from an estimated 410 hours per year under existing conditions to 745 hours per year after development of the West and East Ponds (Appendix A). The number of restricted hours during typical daily flying time (0600 to 2200 hours) will rise from an estimated 310 to 545 hours per year (Appendix A). However, neither the number of restricted hours nor the increases are evenly distributed throughout the year. Maximum increases are predicted to occur

in the late fall through winter (November-March), where the total restricted hours are roughly 320 hours under existing conditions and 645 hours with the proposed ponds. Restricted flying hours show similar changes, rising from an estimated 240 hours to 470 hours below minimum conditions after the proposed ponds.

The approximate effect of the proposed ponds on weather in the North Range can be estimated by subtracting the estimated number of restricted hours before the proposed ponds from the estimated number of restricted hours after the proposed ponds. Because the range is not used 24 hrs/day, impacts to flying hours (0600-2200 hrs) are of principal interest and will be emphasized in the remainder of this document. The anticipated average number of restricted hours/month caused by the ponds, computed by subtracting the total number of hours pre-pond from those in the post-pond scenario (Table A.3 in Appendix A), and dividing by 21 (the total number of years of data) are as indicated in Table 2.

Table 2. Anticipated change in annual average number of restricted hours*/month at the UTTR North Range due to the proposed East and West Ponds

Month	Change in Annual Average Restricted Hrs/Month** Due to Ponds	Change in hours as Percent of Existing Restricted Hours
January	80 hrs	150%
February	28	62
March	6	17
April	11	38
May	0	0
June	0	0
July	0	0
August	0	0
September	1	36
October	3	29
November	37	150
December	80	100

*Represents hours during which ceiling is less than 3,000/ft or visibility is less than three miles.
**Represents flying hours, 0600-2200.

If no ponds were present there would be no increase in the number of restricted hours per month. Thus, the months for which the average number of restricted hours increased significantly (e.g., by more than 50%) of existing restricted hours are of principal interest. As can be seen in Table 2, proposed ponds generally increase the duration and intensity of restrictive weather conditions. The current months of highly restrictive weather conditions, December and January, would thus be extended into November and February. The number of hours would be increased substantially in these months (an average of 120%). Because a slight increase in restrictive weather is predicted to occur from March to April, it is reasonable to conservatively assume that weather in March could also be affected. Thus, the remainder of this document will address weather impacts in the period November-March. No significant increases in restrictive weather conditions are anticipated for the April-October period.

Two weather indices, each realted to the 3000/3 conditions, are of interest and will be used throughout this study. The first is the estimated number of hours/yr of restrictive weather conditions. This index will be used for short duration missions that could be affected by one hour of bad weather but which could then be accomplished later in the day if the weather improves. These are primarily pilot flight and weapons delivery training by TAC and associated units. The second index is the estimated number of days/yr that restrictive weather conditions would occur for three or more hours. This index will be used for longer duration missions that would be cancelled if three or more hours of a day are lost. These are munitions tests conducted by AFLC and cruise missile testing conducted by SAC and others.

The estimated weather impacts of the proposed ponds are anticipated to decrease with increasing distance from the ponds. Based on analyses described in Appendix A, distance from the water body appears to influence weather conditions. Thus, the weather impacts are likely to be experienced mainly in the North Range, and primarily in response to the East Pond. The proposed ponds should have a lesser effect on weather conditions on the UTTR South Range. It is assumed that the effect would be manifested primarily in the northern 5 km of the South Range.

Although not addressed in the weather study, the proposed ponds are expected to increase surface moisture in the target areas by increasing precipitation and decreasing evaporation. Quantifying the magnitudes of these changes with available data and methods of analysis is not possible. In general, the ponds could increase the approximately 6" of precipitation that falls on the West Desert annually. Because of shallowness of the ponds, the effect on precipitation levels is not expected to be great (NAWC 1983). The most likely areas to receive increased precipitation are to the southeast of the ponds, such as the west side of the Grassy Mountains or Cedar Mountains (NAWC 1983). The ponds could decrease evaporation by increasing fog, cloud cover, and humidity in the target areas (principally North Range).

3.1.2 Hydrology

The impacts of West Desert Pumping on groundwater levels in the UTTR are expected to be minimal (Appendix B). The West Pond should not affect groundwater levels at the targets because of the distance between the pond and the target areas. The East Pond offers the greatest potential for impact. Groundwater levels in the northeastern part of the North Range,

where the critical targets Laser Guided Bomb, Big Poppa and Target 22 are located, have the potential to increase at most 0.7 ft. However, because these targets are at least 13 ft above the present groundwater surface, no significant adverse impacts are anticipated.

West Desert Pumping would increase the extent and duration of surface water in the UTTR vicinity. Under normal operation, approximately 460,000 acres of surface water would be created by the proposed ponds; the West Pond would have a surface area of about 374,000 acres, and the East Pond about 88,000 acres. The duration of these proposed new water bodies is difficult to quantify since it is a function of future weather patterns, operating specifications for West Desert pumping, and the development of other Great Salt Lake water level management alternatives. In the event of an accidental dike failure, the areal extent of the proposed ponds would temporarily be greater than that associated with the design surface area, until the dike could be repaired and normal operations resumed. As an example, if the Newfoundland Dike were to fail in such a way that water from the West Pond flowed rapidly into the East Pond area, the water surface east of the Newfoundland Mountains would widen by about 60% and would equilibrate at about 4217 ft elevation. It is estimated that the evaporation and the normal discharge rate through the outlet siphon would lower the water level in the total ponded area to the East Pond design level within one month in warm weather or several months in colder weather. Thus, the extent and duration of surface water in the UTTR vicinity would increase from normal operations of West Desert Pumping, and could increase even more in the event of an accidental dike failure.

Although dike failure in general is of interest in assessing the environmental impacts of the West Desert Pumping Proposal, potential impacts to the U.S. Air Force from dike failure are primarily concerned with the Newfoundland Dike. If the Bonneville Dike were to fail, the water released would likely have only minimal impacts on the South Range because of the topography in the area along I-80 through the West Desert. For example, the elevation of the threshold on which the proposed dike is to be built (>4217 ft) would limit the amount of water that could spill from the 4218 ft West Pond, and the ground elevations along I-80 generally are high enough to contain any water that comes over the threshold (e.g., elevations range from about 4213 ft south of I-80 on the western edge to about 4267 on the eastern edge of the West Desert). Failure of the other proposed dikes associated with the project (railroad dikes and East Pond Barrier Dike) would have minimal impact to the UTTR. Increased surface water from the potential failure of the Newfoundland Dike is thus of principal interest to impacts to the UTTR.

Principal dike failure modes of interest are overtopping and lack of stability. The risk of overtopping the Newfoundland Dike by natural inflow is minimal. Based on data provided by the U.S. Bureau of Reclamation (1977), a 24 hour Probable Maximum Flood (PMF) occurring over a 1,000 mi^2 watershed in northwestern Utah would provide about 65,000 acre-feet to the West Pond. The proposed 6 ft freeboard for this 374,000 acre area would be more than adequate to handle this flow, which would cause the West Pond to rise about 0.2 ft. A repetition of the rapid snow melt (~300,000 acre-feet)

of June 1983 would cause the West Pond to rise about one foot, which still could be safely accommodated in the 6 ft freeboard at the Newfoundland Dike.

The dynamic instability of the Newfoundland Dike under earthquake loading could be greater than that accounted for in the feasibility study design of the dike (Eckhoff et al. 1983). A horizontal acceleration of 0.12 g was chosen in the feasibility study, for design purposes, based on a 10% probability of exceedance in 50 years (Algermissen et al. 1982). Algermissen's estimates are average ground accelerations for sites founded on indurated rock, and therefore may not be representative of conditions in the West Desert. Lakebed sediments such as those in the area of the proposed Newfoundland Dike are susceptible to liquefaction (Mabey 1984), which can occur at accelerations of less than 0.1 g. Furthermore, ground acceleration may exceed Algermissen's estimates by a factor of two, depending on the distance to the epicenter and on foundation conditions. Greater duration of shaking is associated with the soft sediment foundations such as those found in the West Desert. Thus, the Newfoundland Dike as described in the feasibility studies may be subject to failure under earthquake loading. The likelihood of dike failure during an earthquake could be reduced by increasing the strength of the foundation through installation of riprap or through pile driving. The impacts of dike failure could be reduced by implementation of a contingency plan.

Surface moisture in the target areas could be increased after the ponds because of increased precipitation and decreased evaporation. Evaporation is the primary mechanism for removing surface moisture trapped in the soil above the caliche in the West Desert area. Inhibiting this water removal

mechanism while increasing water input could increase the frequency and duration of surface moisture in the target areas.

3.1.3 Land Use

The principal land use impact of the West Desert Pumping Proposal is the removal of about 500,000 acres of Great Salt Lake Desert land from existing uses for pond formation. The ponds may have some effect on limited grazing in the area, and could potentially impact Air Force activities in the area as described in Sect. 3.2.

3.1.4 Ecology

The principal ecological impact relevant to Air Force concerns is the potential for the ponds to attract increased numbers of birds to the West Desert area, thus increasing the potential for collisions between birds and aircraft. The proposed ponds are not likely to permanently attract birds because the salinity of the ponds would not support food resources for birds and because the formation of freshwater marshes (adjacent to the ponds) that would attract birds is not likely. In the original feasibility study, the West Pond was designed for salinity levels ranging from 190 g/L to 322 g/L, and the East Pond (South Railroad Lowline Alternative) was designed for salinity levels ranging from 233 g/L to 350 g/L (Eckhoff et al. 1983). The salinities of the East and West Ponds were never allowed to exceed the sodium chloride saturation concentration of 350 g/L. In the 1985 Update (Eckhoff et al. 1985), the possibility of allowing the salt concentration to exceed 350 g/L for specified time periods (ranging from 4-12 months in the East Pond and ranging from 0-5 months in the West Pond) was examined. The salinity of the proposed ponds is thus likely to vary in location and time. Even the lowest salinity levels, however, are likely to be too high to

produce conditions that will attract birds on a permanent basis. Some temporary increases in transient bird population could occur in areas of lowest anticipated salinity, such as in the intake canal and near the inflow to the West Pond. Thus although it does not appear at present that large number of birds would be attracted to the ponds, the issue is undergoing further study.

3.1.5 Public Health and Safety

Circulating water through a portion of the UTTR and back to the Great Salt Lake offers the potential for the UTTR to act as a source of pollution that could affect public health and safety. Two minor concerns in this area have been identified: the release of chemicals from unexploded ordnance buried in the mud flat areas that would be covered by a proposed pond, and the possible damage of pumping facilities by small unexploded munitions transported from the flooded areas. Construction of a dike on DOD-owned land also presents a safety problem to the construction workers because of the possibility of detonating unexploded ordnance buried in the mud flats.

The potential exists for minor water quality impacts to occur in the Great Salt Lake from the release of ordnance chemicals into the pond waters. Unexploded ordnance with broken casings presents a potential pathway for introducing chemicals into the water. Probable sources of these pollutant releases are targets on which live munitions were or are used, and which would be located in one of the proposed ponds. Only three targets (Nos. 7, 8, and 20, all inactive) meet both of these criteria, and thus represent the most likely sources of water pollution. Any ordnance would also need to be at or near the surface to present a potential pollution source. Each of these target areas has been cleared of ordnance within the last five years,

and the presence of large numbers of the munitions is not likely. However, buried ordnance has been exposed at the surface over time, and even though these targets have been cleared and are inactive, some ordnance could be exposed to surface water by erosion if the proposed ponds are constructed. The release rate of any chemicals present in the ordnance is likely to be slow, and would not result in significant concentrations of chemicals in either the ponds or the Great Salt Lake. Any chemicals released into the ponds would be greatly diluted (and very likely degraded) by the time they reach the Great Salt Lake, and thus would not represent a significant adverse impact to biota or human health in the area.

Small unexploded ordnance currently buried in the mud flats could reach the surface under a pond by channel erosion and be transported by channel currents along the pond bottom to facilities associated with the proposed pumping (such as the control weir or the outlet siphon). It is not clear what amount of damage these small munitions, if detonated, could cause to heavy structures. They could injure personnel and damage rotating equipment, light hardware, and instrumentation. The Air Force recommends that heavy duty "bomb catchers" be installed across the openings of the control weir and the outlet siphon to catch and detonate any incoming ordnance. Because the target areas that would be flooded have been cleared (as discussed previously), the most likely source of ordnance is any previously undetected munitions that have been exposed at the ground surface by erosion. This suggests that the number of unexploded munitions reaching the facilities would be small, and that impacts from exploding ordnance at the weir and siphon are expected to be minor.

The possibility of disturbing unexploded ordnance with a high potential for detonation during construction of the Newfoundland Dike is of concern. The State will construct this dike by excavating 5 ft into the existing material to construct a cutoff wall. To minimize the potential for personnel injury or equipment damage, the project design criteria for the Newfoundland Dike should include a specification for detection and removal of ordnance within about 15 ft of the surface. An area encompassing the 8-mile length of the dike and about 200 ft wide could be cleared to a depth of about 15 ft during the dry summer months in 1985 at an estimated cost of about $440,000 (assumes 75 pieces of ordnance). Appendix C presents more information on the costs of explosive ordnance disposal. The project design engineers could evaluate the location of potential ordnance and determine an optimum course for the proposed dike and identify ordnance for disposal. This would help reduce the possibility of disturbing unexploded ordnance during dike construction.

3.2 IMPACTS TO CURRENT UTTR OPERATIONS

3.2.1 Pilot Safety

The proposed ponds could affect pilot safety by increasing the potential for collisions between aircraft and birds (bird strikes), by eliminating visual clues used by pilots in their approaches to North Range targets, and by decreasing the probability of survival after ejection over the West Desert area. Also, increased corrosion to aircraft parts because of higher ambient levels of salt particles would increase maintenance, and could endanger pilots if required maintenance is not performed.

The proposed ponds are not likely to result in a significant bird/aircraft collision hazard at the UTTR. As discussed in Sect. 3.1.4, the anticipated salinities of the proposed ponds, plus the anticipated lack of fresh water marshes adjacent to the ponds, should discourage use of the ponds and surrounding areas for feeding or nesting purposes. Minor increases in bird/aircraft collisions could occur due to transient birds visiting the proposed ponds and/or saltwater marshes that could arise. Given the anticipated temporal and locational variations in pond salinity, the potential for bird/aircraft collisions should be seasonal in nature and non-uniformly distributed over the project area. In addition to the probability of a collision occurring, the consequences of the collision are also of interest. Based on data collected at Hill AFB, bird/aircraft collisions usually do not result in loss of life or loss of an aircraft. For example, the 388th Tactical Fighter Wing stationed at Hill experiences an average of over 5 bird/aircraft collisions per month; however, only one loss of an aircraft resulting from a collision is on record. Any collisions occurring over the UTTR because of the proposed ponds would likely exhibit similar statistics. Thus, the proposed ponds are not presently expected to significantly increase either the potential for bird/aircraft collisions or the consequences of such collisions. However, this issue is still being studied by the Air Force.

The presence of large, shallow lakes under the flight path of aircraft will result in the loss of visual clues, such as consistently perceptible range floor and an adequately defined horizon, presently available to air crews. The possibility of a mishap occurring, especially at night, will be increased as a result of the proposed West Pond. This will force adjustment

of flight operations by either changing flight restrictions (elevations), altering the flight paths to avoid the West Pond, or relocating certain missions (tests) to other test ranges.

The proposed water bodies represent a serious hazard for airmen who are forced to eject from the aircraft in the North Range area. Due to the salinity of the water in the proposed ponds, the surfaces will not freeze. In the winter, the brine in the proposed project ponds would be colder than 0°C, resulting in a reduced potential for post-ejection survival of air crews. An airman could lose consciousness in a matter of minutes under such conditions. With rescue response times of approximately 45 minutes, the survivability of any personnel ejecting into the proposed ponds is questionable. As the ponds will overlay mud bottoms, survivability of personnel ejecting into the proposed project area will be affected throughout the year. Air crews parachuting into the ponds may sink into the bottom as a result of the impact, and may drown in the shallow waters. Aircraft impacting the pond may be non-recoverable, preventing mishap reconstruction. To avoid losses of airmen or equipment, flights at low-levels would need to be re-routed to minimize flight time and distance over the shallow ponds. However, the capability to do this would be limited because of the boundary of the restricted air space and the locations of the targets.

Increased corrosion of aircraft could occur from low level flight over the ponds, and could present a safety hazard. Wind action on the ponds will create waves, resulting in an increase in airborne salt particles in the atmosphere over and downwind of the proposed project. The increase in the number of these salt particles will result in additional fog, stratus

clouds, and low-level haze over the UTTR. Flight operations through these particles will subject aircraft to additional corrosion, and may affect aircraft avionics. Aircraft at Hill AFB presently avoid the major airborne salt particle effects of the GSL by relatively high altitude flight paths over the GSL. The proposed project will subject aircraft using the UTTR for low-level air-to-ground operations to additional corrosion, perhaps of a magnitude similar to that experienced by coastal units.

The proposed East Pond could also pose safety problems for pilots and ground personnel in the area of the Laser Guided Bomb target. At the target, a laser is fired to the northwest through a tunnel to a target that reflects the beam upward. If the beam for some reason is not reflected upward, it currently is absorbed by soil and vegetation in the target area; however, a water body located to the northwest of the target could reflect the beam and cause an eye hazard for airborne and ground personnel.

3.2.2 Target Accessibility

The presence of surface water on or near the UTTR could inhibit target accessibility and hinder target operation. Targets on which live ordnance is used must be accessible by ground vehicles and must be relatively clear of surface water so that the Air Force can perform target maintenance and clear the targets of unexploded ordnance. Air Force regulations require surface ordnance clearance of scorable targets (e.g., Eagle Range) once a month, and clearance of non-scorable targets at least once per year. All UTTR target areas must be cleared once every five years. Thus, to be fully operational, targets on which live ordnance is used must be cleared as required by Air Force regulations. Although targets are located throughout the UTTR (Sect. 2.2), targets in the North Range are of principal interest

because of their proximity to the East Pond and West Pond. The accessibility and full operation of any targets located in the flooded portions of the North Range could be hindered by the proposed ponds.

A variety of targets and target complexes exist in the North Range, as shown in Fig. 11. Live ordnance targets are Nos. 1, 2, 3, 5-14, 21, 23, 24 and 26; live ordnance is also used on Eagle Range, the Helicopter Air-to-Ground (HAG) area, Cluster Bomb Unit (CBU) Valley, Big Poppa. The remainder of the Targets (15-20) involve inert ordnance (target number 4 does not exist). Targets 3, 11, 13, 14, 18, 21-24, 26, HAG, CBU Valley, Big Poppa and the LGB complex are actively used; the remainder of the targets are currently not used, but may be reactivated in the future. Critical targets, which are those that are essential to continued operation of UTTR, are 1, 3, 13, 21, 22, 23, 24 and 26, plus Eagle Range, CBU Valley, Big Poppa and the LGB complex. The critical targets extend from a point approximately seven miles southeast of the Newfoundland Mountains north-northwest toward Hogup Ridge to an area referred to as The Threshold. The targets are all located within the sand dune area just east of the flats, and they are generally 10 to 20 ft higher in elevation than the adjacent mud flat area. The targets range in size from approximately one-half acre to over 900 acres in surface area. The surfaces of most of the targets have been roughly graded to remove vegetation and provide surface identification features for the air-to-surface bombing. In general, little more than the upper 6 to 12 inches of soil and surface vegetation has been removed or graded. Therefore, the targets generally follow the original topography with little or no specific surface drainage grading having been performed. The surface

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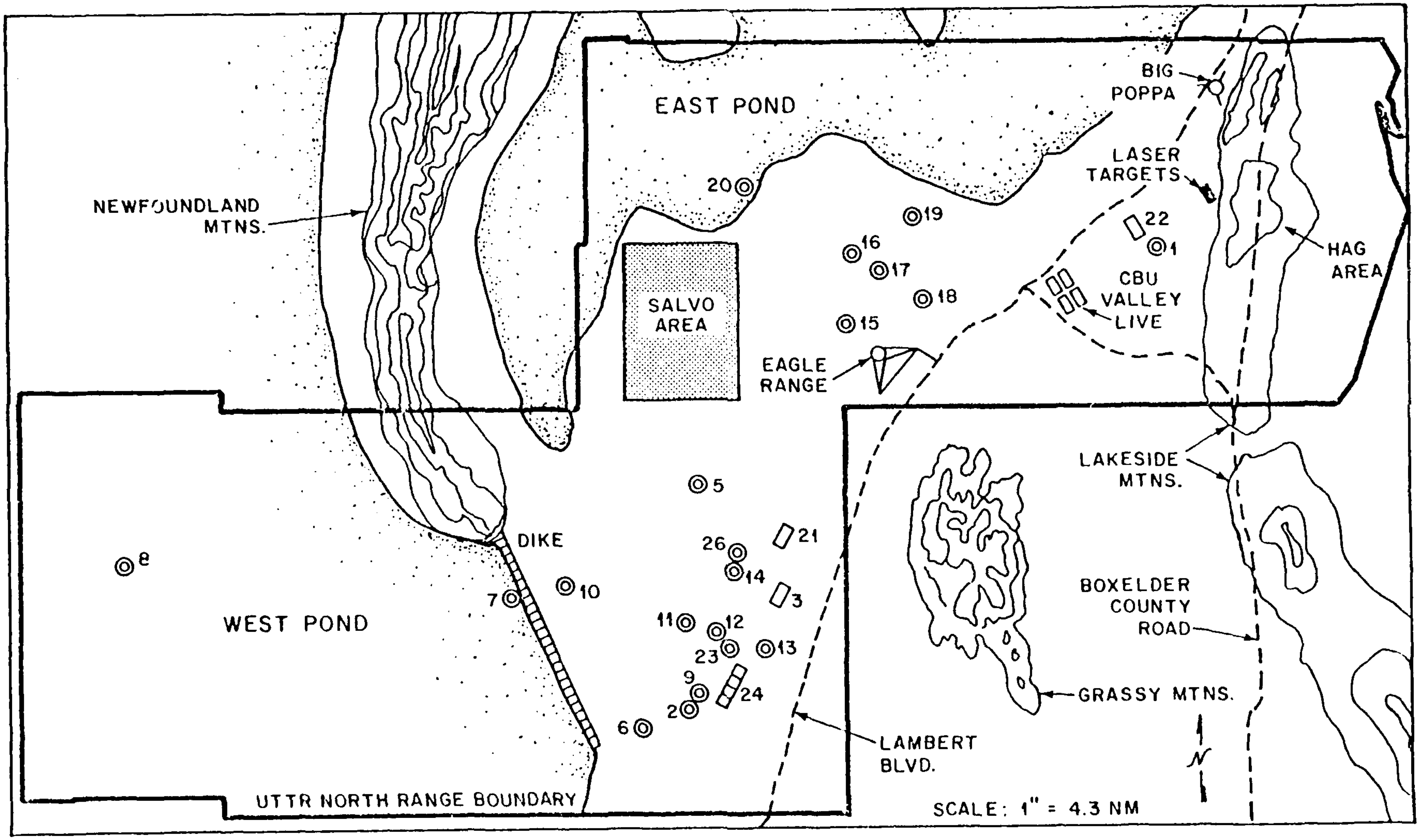

Figure 11. Locations of UTTR North Range targets and proposed ponds.

topography adjacent to the targets consists of sand dune and mud flat areas with generally poor drainage conditions and some standing water areas.

The accessibility of a number of North Range targets could be affected by the proposed ponds. As shown in Fig. 11, Target 8 would be surrounded by the proposed West Pond, and Targets 7 and 20 are located within the proposed West and East Ponds, respectively. Targets 6, 10, 19 and 22, and Big Poppa and the Laser Guided Bomb targets, are located near the proposed ponds, but will probably remain unflooded. The shapes of the proposed ponds as illustrated are not exact because of a lack of detailed topographic information for the area (especially with respect to the southern boundary of the East Pond). Live ordnance Targets 7 and 8 would be made either inaccessible or of limited accessibility by the proposed ponds, and live ordnance Targets 6 and 10 could be similarly affected depending on the actual shape of the proposed East Pond. Because these targets are not currently used on a routine basis and are not critical to UTTR operations, impacts due to inaccessibility from direct flooding are not expected to be significant.

The potential inaccessibility of critical targets through the inhibition of surface drainage is not expected to be significant. Initially, it was thought that the proposed ponds could inhibit surface water drainage in the critical target areas by raising the groundwater levels under these areas. However, a geohydrology study conducted in early 1985 (Appendix B) found that neither the proposed West nor East Ponds would aggravate existing accessibility and trafficability problems in the target areas. Groundwater levels were found to be 6 to 17 ft below the critical targets. The proposed West Pond would increase hydrostatic water levels at

the Newfoundland Dike by about 3 ft; however, these heads will be dissipated within one-half mile of the dike. Since the closest critical targets (Targets 23 and 24) are well beyond this distance, no increases in groundwater levels beneath the targets are anticipated. Even water levels beneath some of the "non-critical" targets that are closer to the dike (e.g., Targets 2, 6, 9 and 10) would not be increased to the extent that they inhibit surface drainage. The effect of the proposed East Pond on critical targets is somewhat greater, but is also not significant. Target 22, the LGB target and Big Poppa are the closest critical targets to the East Pond. Groundwater levels have the potential to increase about 0.7 ft at the LGB target and less than 0.2 ft below Big Poppa and Target 22. However, because these targets are at least 13 ft above the present groundwater surface, no impacts are anticipated. In addition, no impacts should be observed if the East Pond level increased to 4217 ft MSL because of failure of the Newfoundland Dike.

The existing accessibility and trafficability problems in the critical target areas are thought to be due primarily to poor surface water drainage conditions. The presence of a subsurface caliche layer with severely reduced vertical permeability contributes to the poor drainage. One exception to this is the wet area located on the north side of Target 21. Based on groundwater level measurements taken in early 1985 and on topographic information on USGS quad sheets, it appears that this area of Target 21 is below the groundwater level, hence the repeated occurrence of excessive surface moisture (Appendix B). For the most part, however, the trafficability and accessibility problems in the North Range critical

targets are not related to present or future groundwater conditions in the target areas.

Target accessibility could also be hampered by poor conditions on Lambert Blvd. and Box Elder County Road caused by passage of heavy construction equipment. These roads could be used for transport of construction personnel from a proposed Lakeside base camp to the Newfoundland Dike Construction area. No routine heavy hauling or other heavy traffic on these roads is anticipated. Transportation of heavy equipment to the Lakeside area is anticipated to be done along the SPRR causeway. The West Desert Pumping feasibility study proposes construction of roads along the SPRR causeway for activity north of the North Range, and upgrade of existing jeep trails on the east side of the Newfoundland Mountains for activity related to the Newfoundland Dike construction. The contractor would thus have access to the Newfoundland Dike area from the SPRR causeway, and is not likely to use, on a routine basis, the two roads that are needed for Air Force operations and that are maintained with Air Force funds. Adverse impacts to these roads from construction activity could occur; the degree of impact can't be quantified at present. The costs of restoring the roads to their pre-project condition should be borne by the state.

Target accessibility would also be adversely affected by increased surface moisture caused by the weather impacts of the proposed ponds (Sect. 3.1.1). As discussed in Section 3.1.2, the target areas currently suffer from poor surface water drainage. The proposed ponds would add to the surface moisture through increased precipitation and decreased evaporation (caused by more clouds, fog, and increased humidity). Wet target areas

would adversely affect all target users, and AFLC in particular. An essential part of munitions testing is the physical counting of duds on the target surface. If this can't be accomplished due to excess surface soil moisture, completion of missions would be delayed. Possible mitigation includes improving surface drainage, perhaps through the installation of French drains (Appendix B). The need for and extent of a drainage system for each target would be determined in a post-operational assessment of the effects of the proposed ponds. It is estimated that a gravel-filled French drain 4 ft deep and 2 ft wide would cost about $5-$6 per linear ft. For a target approximately 1 mi with drains on 100 ft intervals, the cost of French drains would be about $1.5 million (Appendix B). These costs should be borne by the state.

3.2.3 Aircraft Flight Restrictions

The proposed ponds would restrict aircraft flight operations in the UTTR by the presence of construction parties and water bodies (proposed ponds). Air Force regulations prohibit performance of certain activities over populated areas and establish minimum altitudes for flights over water bodies. Present flight paths over areas that will experience construction activity or that will be flooded will need to be modified to conform with Air Force regulations.

Air Force regulations do not permit test or training flights with live and armed munitions over civilian populations. Because many of the existing flight paths employed by aircraft using the North Range fly over the location of the proposed Newfoundland Dike, flight paths would need to be temporarily modified or construction crews removed from the dike area during operations. For pilot training, flights could be re-routed either to the

north or south of the work crews at the proposed dike or at sites of borrow material proposed for the North Range. None of these flight path modifications are expected to be significant. For AFLC munitions testing, flight paths could not be similarly modified because they follow a fixed route determined by the locations of optical telemetry equipment used to track the aircraft and the munitions being tested (Sect. 3.2.4.1) and the locations of the targets. Consequently, the AFLC munitions testing flights would pass over the work crews for the proposed dikes. Because of the nature of the munitions testing, the AFLC aircraft would not be able to be disarmed upon approach to the areas with the work crews. Therefore, to comply with Air Force regulations, the work crews would need to be removed from the UTTR area during AFLC operations; it is estimated that this would need to be done about 2-3 hrs/week during 9-month construction period. If necessary, the construction workday hours could be adjusted to accommodate the test time.

Air Force regulations also prohibit the use of live ordnance targets if civilian population is nearby. To continue normal operations, an area 6,000 ft surrounding an active live munitions target and 12,000 ft beyond the target on the axis of attack must remain clear of construction activity. No operations are possible if the targets are encroached nearer than 4,500 ft. All of the currently active live munitions targets are beyond 4,500 ft from either the proposed Newfoundland or East Barrier Dikes, which represent the closest construction activities to the North Range targets; also, construction crews would be working more than 12,000 ft in the line of attack from any target. Consequently, temporary cessation of activity at the targets due to the presence of construction crews is not likely.

The creation of the proposed West Pond could impair current low-level flight training exercises. At present, virtually all TAC sorties from Hill AFB scheduled for Eagle Range transit north of the Newfoundland Mountains, proceed southward on the west side of the mountains, then turn to the northeast past the southern tip of the mountains into the North Range (i.e., most of the ingress passes over the area of the proposed West Pond). This route is flown at low-level (100-500 ft AGL) altitudes to allow pilots to conduct low-level flight training on their way to weapons delivery training in the North Range. For primarily safety reasons (Sect. 3.2.1), TAC training directives limit aircraft to a minimum altitude of 1,000 ft AGL over a body of water the size of the proposed West Pond. If the pond is constructed, current flight paths would need to be modified to maintain low-level flight training on approach to Eagle Range; if the modified paths increase transit time, then training time could be lost because sorty length is fixed. Alternatively, low-level flight training could be combined with sorties over other areas not proposed to be flooded. Low-level flight training in accordance with TAC training directives along presently used flight paths upon ingress to Eagle Range could not be conducted if the proposed West Pond is constructed.

Neither TAC's use of Eagle Range nor AFLC's use of the North Range targets are expected to be significantly affected by the proposed ponds. Ingress to the North Range could be conducted at 1,000 ft altitudes over the proposed ponds. Egress is typically eastward over the Lakeside Mountains, and should not be affected by the proposed ponds.

3.2.4 Weather

3.2.4.1 Range Use

The estimated weather impacts of the proposed ponds could adversely affect operations of a number of range users. In general, the proposed ponds are likely to increase the duration of weather conditions representative of the winter season and to increase the number of restricted hours in the months within that season. As discussed in Sect. 3.1.1, the proposed ponds could produce an estimated monthly average increase in the number of hours for which the 3,000/3 weather conditions (Sect. 2.1.1) would not be met if the proposed East and West Ponds are constructed. Because a number of range users have minimum weather conditions that are more stringent than a 3,000 ft ceiling and 3 miles visibility, the number of restricted hours could exceed those given above. However, since the anticipated meteorological effects of the proposed ponds would likely be confined to the low altitudes and to within several kilometers of the proposed pond shoreline, the 3,000/3 conditions are thought to be generally representative of restrictions affecting all range users.

Each of the major commands using the range would be affected, to some extent, by the weather impacts of the proposed ponds. The two major commands that use the North Range most often are Tactical Air Command (TAC) and Air Force Logistics Command (AFLC). About 90% of the North Range missions flown in FY 1984 were by AFLC (10%) and TAC (80%). SAC (and other cruise missile testing organizations in the Air Force) uses the North and South Ranges for their activities.

The air-to-ground tests of munitions by AFLC involve shelf/service life testing, engineering tests, and the testing of aircraft and computer systems

as they interface with the munitions. During many of the tests, sophisticated photographic equipment is used to record the performance of the munition. These programs require good weather with visibility to 15,000 ft above ground level (AGL). This testing is conducted using Targets 13, 21, 22, 23, 24, and 26, the Laser Guided Bomb (LGB) target and Cluster Bomb Unit (CBU) target. Eagle Range is also used for practice runs where immediate results are desirable. Target 21 is the only target in the world available for the Air Force to test delayed detonation bombs. Explosive ordnance disposal teams clear each target of munitions as part of the test to count duds and misfires. Approximately 370 munitions testing sorties were forecast for shelf life/service tests on the UTTR in FY 1985.

AFLC would be restricted on their use of the range under the predicted weather impacts of an estimated 20 days with three or more hours at below minimum conditions (flying hours during the November-March winter time period). The AFLC generally schedules about 455 flight exercises or sorties during the November-March training period. In October-March, 1984, current weather conditions in the North Range caused about 194 cancellations. The estimated 20 additional days in which three or more hours would experience restricted weather would increase the number of cancelled sorties by about 75. The net increase in restricted weather by the ponds would decrease the numbered suitable flying days by about 10%. These additional cancellations would increase the Air Force munitions testing costs since additional sorties would need to be scheduled to maintain the current munitions testing level of 158 sorties (October 1983-March 1984). Delays in munitions testing cost AFLC between \$5,000 and \$10,000 per cancelled test. Assuming five

sorties are required per munitions test, the cost to the Air Force would range between $75,000 and $150,000 per winter testing period (November-March) in any given year.

The TAC operations on the North Range involved about 6,400 bombing and strafing runs on the Eagle Range targets in 1984. TAC operations consist primarily of pilot flight training and weapons deployment training. Flight training involves aircraft maneuvers at various altitudes, climbs, dives, and low altitude flight and navigation. (Air-to-air combat training is also conducted.) Weapons deployment training includes bombing and strafing practice (air-to-ground operations). Typically, low altitude training and navigation are conducted in conjunction with approach to Eagle Range for weapons deployment training. TAC also conducts training in the South Range; activities include air-to-air gunnery training (against towed targets) and air-to-ground operations at Wildcat Range, Kitty Cat Range, and Baker's Strongpoint. Minimum weather requirements for these air-to-ground missions range from 3,000 ft AGL ceiling, 3 miles visibility for a 10° dive to 15,000 ft AGL ceiling, 3 miles visibility for a 45° dive. Strafing requires a minimum 3,000 ft AGL ceiling and 3 miles visibility. To reduce altitude for low altitude work, minimum requirements are a 4,000 ft ceiling and 5 miles visibility. Low altitude exercises requires a minimum of a 2,000 ft ceiling, 3 miles visibility on the range and a 1,500 ft ceiling, 5 miles visibility to navigate.

TAC would be restricted on its use of the range under the predicted weather impact of an estimated decrease of about 230 hrs/yr of weather conditions below 3,000 ft ceiling/3 miles visibility in the November-March period during flying hours. Currently about 2,750 flying hours are

available to TAC at Eagle Range (most of TAC's North Range activities are done at Eagle Range). The expected loss of about 230 hours of Eagle Range flying time represents about 8% of TAC's current range use. TAC's existing attrition rate, which is caused by weather cancellations, maintenance, etc., is a historically derived 16%. The increased hours of restricted weather would thus increase the attrition rate to about 24%. To maintain desirable combat capability for pilots, TAC would need to increase its scheduled sorties from 6147/yr to 7622/yr. This would apply to TAC activities in the North Range as well as those in the northern 5 km of the South Range. The scheduling implications of these changes, and associated costs, are addressed in the next section. This represents a maximum or worst-case loss of time because it assumes that all of the bad weather days caused by the ponds occur on days in which weather conditions at Hill AFB (or other home base) allow aircraft to take off. In realty, some of the restricted weather hours at the UTTR would occur in conjunction with hours that experience restricted weather at Hill AFB, such that aircraft could not take off to use the UTTR; hence, the net loss of UTTR time would be less.

Strategic Air Command conducts cruise missile testing in the North and South Ranges. Within the North Range Military Operating Area (MOA), the flight path is generally confined to the northwest of the area of the proposed ponds. In the South Range MOA, the flight path crosses the northern part of the MOA and thus would encounter any restrictive weather conditions from the proposed ponds. It will be assumed that the full predicted effect of an additional 20 days per winter time period with 3 or more hours of below minimum conditions (flying hours) will apply to SAC cruise missile testing activities. The usable flight days between November

and March for SAC operations is currently about 45 days. This represents usable flight days after days have been cancelled due to cloud cover (1983-1984 data). The estimated 20 additional days of restricted weather conditions would reduce usable flight time to only 25 days for the five month winter period. This will produce an etimated 50 percent increase in costs to SAC due to increased ground and air cancellations. Based on recent cruise missile testing cancellation data, the costs for nine ground cancellations and one air abort, which are estimated to result from the 20 additional days of restricted weather, is about $590,000 per winter time period for any given year. This analysis assumes a worst-case situation in which cruise missile tests were assumed to be scheduled on each day of predicted restrictive weather.

The meteorological effects of the proposed ponds could also impact range use (principally AFLC activities) by affecting the operation and performance of ground based instrumentation used in the weapons testing activities. Cinetheodolites, which track and provide film records of flights, could be affected if visibility does not allow adequate tracking of aircraft. The cinetheodolites require good visibility for camera tracking of aircraft, missiles, etc., and would be adversely affected by fog or haze. The cinetheodolites are located in the North and South Ranges; those in the North Range, to the southeast of the East Pond (along Lambert Blvd., about one-half mile from the munitions test targets), and those located in the northern 5 km of the South Range could be affected by adverse weather from the proposed ponds. The net decrease in range use by weather-related

shut-down of the cinetheodolites may be minimal because it may coincide, for the most part, with days on which flights were cancelled anyway because of weather conditions.

The HAMOTs, which are solar powered instruments that have the capability to track multiple aircraft in flight, could be without power if adverse weather conditions from the ponds prevent battery recharge. HAMOT sites are located throughout the UTTR. No HAMOTs are presently located in the North Range; however, twelve sites within the North Range restricted airspace have been selected for future development with HAMOT instrumentation. Most of these sites are close enough to the proposed ponds to be affected by the anticipated weather impacts. Any fog or cloud cover caused by the ponds would need to be continuous for a period of seven or more days to adversely affect the solar-charged batteries in the equipment. Because the likelihood of this weather event is small, impacts of the proposed ponds on HAMOT performance are not expected to be significant.

3.2.4.2 Range Scheduling

The estimated weather impacts of the proposed ponds (Sect. 3.1.1) could adversely impact scheduling the use of the UTTR. As discussed in Sect. 3.1.1, and Appendix A, the proposed ponds are anticipated to increase the number of restricted hours in the North Range. For the winter months (Nov.-Mar.) of 1983-1984 and 1984-1985, an average of about 220 hours/month were flown in the UTTR North Range. The projected average monthly restrictions (Table 2) range from a low of about 3% of average winter hours flown (in March) to a high of about 40% (in January and December). The proposed ponds are also estimated to produce an additional 20 days/yr in which three or more hours would experience restricted weather conditions.

These can represent appreciable percentages of the days of range use for various MIACOMS, and could lead to schedule changes that adversely affect the range users.

AFLC is a higher priority range user (Sect. 2), and can bump pilot training from the schedule to conduct its munitions testing. Also, AFLC has some seasonal flexibility in its schedule in that missions cancelled in the winter due to weather conditions could be rescheduled for summer months when there is a greater probability of good weather. If the weather impacts of the proposed ponds prevent continued use of the munitions test targets, either through restricted flight conditions or through reduced target accessibility, AFLC would be seriously impacted. Some tests could be transferred to existing targets at other ranges. This would entail shipping the munitions, operating and support personnel, aircraft and equipment. Transferring a munitions test to the nearest suitable range (usually in Nevada) is estimated to add about $110,000 to the cost of a test. If a suitable range can't be found for transferring a test, then the target itself would need to be moved. Some of the targets could not be moved to other ranges without significant costs and time requirements for land acquisition, engineering and construction. For those targets that could be moved elsewhere, costs would also be significant. Moving a fully instrumented munitions test target is estimated to cost about $67 million (1983 dollars). These costs should not be borne by the Department of Defense. TAC would be affected by scheduling problems if the higher priority range users must reschedule their activities. TAC is a lower priority range user and is more likely to be bumped from the schedule. Also, because pilots must maintain their training currency year round, TAC

does not usually have the option of rescheduling activities to the summer months. Consequently, if TAC would not be able to use the UTTR for training it would be forced to train at another range for the restricted weather periods. Moving the entire 388 Tactical Fighter Wing to another range would cost about $2 million/month. If this would need to be done for the entire five-month winter weather period, costs could be as high as $10 million annually.

3.3 IMPACTS TO FUTURE OPERATIONS

Impacts to future range uses that represent continuations of current activities would be similar to those described in Sect. 3.2. Activities that are expected to increase in the future and which would face restricted range time because of the proposed ponds would likely face similar impacts to those in Sect. 3.2 but of greater magnitude. For example, TAC is investigating the feasibility of basing an additional fighter wing at Mountain Home AFB, Idaho, that would require about 300 hours/year of UTTR range time (most likely at the Eagle target complex), if available. The unavailability of this time on the UTTR would have a strong effect on the decision to base the proposed wing at Mountain Home AFB. Impacts to the proposed Electronic Combat Range (ECR) are difficult to evaluate since its location within the UTTR has not been decided; however, areas that could be impacted by restrictive weather conditions from the proposed ponds are within those being considered for the ECR. The proposed Weapons System Evaluation Program will probably be located in the South Range, and thus is not likely to be significantly affected by the proposed ponds.

Lastly, the SAC cruise missile testing operations are generally considered to be a high priority range use and thus are not likely to be seriously affected by range scheduling. If the proposed ponds cause a noticeable increase in either air aborts or ground cancellations, thereby triggering rescheduling of SAC missions, other range users could be affected.

4. SUMMARY AND CONCLUSIONS

4.1 SUMMARY OF IMPACTS

This report has addressed the impacts to the UTTR of various alternatives for managing the level of the Great Salt Lake. The report has focused on the State's preferred alternative (West Desert Pumping) and on the State's preferred option for implementing West Desert Pumping (East Pond and West Pond). Other options for managing the lake level (e.g., lake diking and upstream river diversion or storage) would have negligible, if any, adverse impacts on UTTR operations until the lake level exceeds 4215 ft MSL (which is a low probability event), when the East Pond area would naturally start to flood. The primary impact of the other options would be beneficial to UTTR in that they would eliminate and/or minimize the need for West Desert pumping. The State should give serious consideration to developing and implementing a medium/long-term solution to controlling the lake level so that the short-term options of West Desert pumping and/or lake diking will not be critical factors in preventing or minimizing future flooding.

Table 3 summarizes the potential impacts to UTTR operations from the proposed West and East Ponds. Impacts are organized into four major areas of concern: pilot safety, target accessibility, flight restrictions and weather.

4.2 CONCLUSIONS

Conclusions that can be drawn at this time with respect to the impacts of Great Salt Lake water level management alternatives on UTTR operations are that the long term options for managing the lake level (e.g., diking,

Table 3. Summary of potential impacts to UTTR operations

Impact Area	Impact
Pilot Safety	• Loss of visual cues • Decreased chance of post-ejection survival • Possibility for slight increase in potential for bird/aircraft collisions
Target Accessibility	• No significant effect on target drainage • Three currently inactive targets would be inaccessible due to surface water • Weather effects could increase surface moisture on targets and hamper accessibility.
Flight Restrictions	• Surface water will change low level training flight route currently followed on ingress to Eagle Range • Dike construction and borrow material excavation work crews will temporarily change flight ingress to Eagle Range. Crew removal may be required for some overflights
Weather	• Weather conditions below 3,000/3 during flying hours (0600-2200) would increase an estimated 230 hrs/yr (maximum), primarily in winter and in the North Range and Northern South Range; an additional 20 days with 3 or more hrs of below minimum conditions would result in winter. - About 10% decrease in AFLC winter flying days (maximum) - About 8% (maximum) of TAC's currently available flight hours would be lost due to weather - About 40% (maximum) decrease in usable winter days for SAC cruise missile testing • Lost hours would be made up on another range or rescheduled in summer at UTTR, at increased cost to the Air Force. Low priority range users could be bumped from schedule

upstream diversion, storage, etc.) would have minimal, if any, adverse impact on UTTR, and that the State's preferred alternative for implementing West Desert Pumping would affect some UTTR operations by increasing time at below minimum weather conditions (3,000/3) in the North Range, and to a lesser extent in the South Range. Modifications to the groundwater regime would be insignificant.

Based on the current descriptions of the State's proposal, the following summarizes potential impacts to each of the major commands (MAJCOMs) using the UTTR:

- Air Force Logistics Command operations would be principally affected by an increase in below minimum weather conditions during winter months that prevent aircraft activity in the North Range, or that prevent operation of optical tracking systems used in munitions testing;
- Strategic Air Command and others involved in cruise missile testing could be affected by an increase in below minimum weather conditions, in the northern part of the South Range;
- Tactical Air Command (TAC) operations would be affected primarily by an increase in the number of hours/year unsuitable for flight; flight restrictions caused by the ponds and pilot safety issues could also affect TAC operations to some extent; and
- Air Force Systems Command (AFSC) test programs (i.e., cruise missile component testing) would be only marginally affected by the ponds; however, the AFSC mission of scheduling and operating the UTTR in support of other MAJCOM programs could be affected to the degree that other MAJCOM programs are impacted. In addition, the costs of management, coordination and surveillance could increase due to the presence of increased civilian population associated with the proposed ponds.

The costs of impacts to the Air Force and the costs to mitigate any impacts identified (Sect. 4.3) should be borne by the state. The costs of some of the impacts discussed in Section 3 are significant when compared against the approximate $50 million cost of West Desert pumping. Because these impacts are estimates based on predictions and assumptions, it is important for the Air Force to monitor anticipated impact areas (e.g., flight cancellations due to weather, days of target inaccessibility, etc.) should the proposal be implemented. This information would help in quantifying impacts resulting from the state's action and in identifying costs of resultant impacts.

4.3 MITIGATION

Changes in the proposed action could influence the magnitude of potential impacts to some extent. Removal of the East Pond, which is an alternative for implementing West Desert Pumping (Sect. 1.3), is not likely to substantially reduce the magnitude of potential impacts on pilot safety or flight restrictions. However, removal of the East Pond could have a slight beneficial effect by reducing the number of hours/year below 3,000/3 conditions at Eagle Range and other targets south of the East Pond area. All impacts could be further reduced by minimizing the use of West Desert Pumping in Great Salt Lake water level management.

Changing flight routes for approach to the North Range would mitigate pilot safety and flight restriction impacts resulting from overflight of water bodies and construction crews. At least two options are available. First, low-level flight training on approach to the North Range targets could be accomplished by flying southward over the eastern flank of the

Newfoundland Mountains; this would produce only minimal overflight of the proposed water bodies, and would actually decrease current transit time. However, conflicts in traffic patterns could occur because concurrent missions in the North Range are somtimes conducted; special scheduling would then be required to avoid conflicts. A second route would be to fly completely around the proposed West pond in a counterclockwise pattern that would approach the North Range from the south (to the east of the Newfoundland Mountains). This would eliminate overflight of any of the proposed water bodies, but would increase transit time because of the longer distances. Because the lengths of sorties are fixed due to fuel reserves and maintenance schedules, the increased transit time would decrease the time available for training. The potential impact of decreased post-ejection survival could be mitigated to some extent by enhancing the emergency response capability for downed pilots. Changing flight paths to avoid construction crews in the vicinity of the proposed Newfoundland Dike could be done with minimal impact to training activities. However, there may be instances where the construction crews can't be under an overflight path. In this case, the crews would have to be removed from the area until the testing mission is complete. It is estimated that this would be done about 2-3 hrs/week for the 9-month dike construction period. If necessary, the construction workday hours could be adjusted to accommodate the test time. Target inaccessibility due to increased surface moisture from the proposed ponds' weather effects could be mitigated by the installation of French drains, which is estimated to cost about $1.5 million for a 1 mi target. Possible impacts from laser reflection on the proposed ponds could be mitigated by reconstructing the laser tunnel with an orientation directed

away from the ponds. Temporary relocation of UTTR activities can also be considered as a mitigation measure. Transferring munitions tests to another range would add about $110,000 to the cost of a test. Temporary relocation of a tactical fighter wing would cost about $2 million/month.

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APPENDIX A

REVIEW OF STATE-FUNDED METEOROLOGY STUDY
AND ASSESSMENT OF THE WEST DESERT
PUMPING PROPOSAL ON METEOROLOGY IN THE
UTTR NORTH RANGE

REVIEW OF STATE FUNDED METEOROLOGY STUDY
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PUMPING PROPOSAL ON METEOROLOGY IN THE UTTR NORTH RANGE

A.1 REVIEW OF METEOROLOGY STUDY

A review of the document "Estimated Impacts of West Desert Pumping Alternative on Local Weather," by Elliott, Thompson, and Griffith, NAWC Report SLWM 85-1 has been completed by Oak Ridge National Laboratory for the U.S. Air Force at their request. The authors should be commended for accomplishing a great deal of work in a short time frame. However, it appears, for reasons discussed below, that the results of the work would be of only limited value to assessing the impacts of West Desert pumping to UTTR operations.

Data from the Eagle Range should not be used in this study. Observations are made at Eagle only during the time when flights appear to be possible. The data set is biased, not random, and cannot be used to compare with data collected at Salt Lake City (SLC) International Airport or at Dugway. Although the Eagle Range location is ideal for this study, the bias in the data invalidates any conclusions that are reached. The bias in the data which has been noted by Hill AFB weather personnel, cannot be removed from the data by any filtering or data manipulation.

A major finding of the multiple regression analysis (pg 5-19) is that lake level, used as a surrogate for fetch, plays a "rather insignificant role" in the number of hours of below minimum flying conditions. However, this finding is ignored in the conclusions, where the size of the proposed pond (1/3 of the Great Salt Lake) is used in a one-to-one reduction of the

effects of the pond (pg. 10-2). The discrepancy is not explained, and cannot be supported by the data and analysis contained in the body of the document.

The mathematics used to estimate the additional hours of fog due to the ponds are incorrect. The total stagnant hours at Eagle are indeed about 22% of the total stagnant hours at SLC (154/686). However, this does not imply that SLC has 78% more hours, but SLC has 445% more hours (686/154). The reasoning on pg. 10-2 to arrive at an annual increase of 15 to 30 hours is based on this incorrect 78% assumption, and makes the findings of the study of limited value. The mistake could be rectified by properly calculating the increases in minimum hours, but the basic conclusion that can be drawn from the study is that Eagle Range is likely to have about the same number of hours after the pond is built as Salt Lake City airport presently enjoys.

Because the NAWC study is based upon the biased Eagle Range data and contains one discrepancy in the effects of fetch on fog formation, and mathematical errors, preliminary conclusions on the effects of the ponds on Air Force operations at North Range activities were developed by ORNL staff, is discussed in the following sections.

A.2 ASSESSMENT OF IMPACTS

Difficulties in the study of potential pond influences on weather conditions in the UTTR North Range include the lack of unbiased data at the range, lack of a validated model to predict the effects of lakes on flying conditions, and the lack of a surrogate lake system at which lake effects on flying conditions could be investigated. Meteorological data from the range

are biased due to the times when observations are taken, and thus do not provide a useful climatology of restricted flying conditions at the range. An alternative source of meteorological data must be used to represent the present and past conditions at the range. No model to accurately predict the effects of a body of water on visibility and low cloud formation is available, and the state-of-the-art in atmospheric modeling will not presently support such a code. No surrogate lake system similar to the proposed ponds in size (460,000 acres), salinity and depth of water has been formed during recent times from which conclusions on the effects of such lake formation could be drawn. Because of these difficulties, an analogy between locations presently near the Great Salt Lake and locations near the proposed new ponds will be drawn, and used to predict the effects of lake formation on weather conditions on the UTTR North Range.

A search of available meteorological data for the UTTR/Great Salt Lake vicinity identified two data sets for the appropriate locations, length of record and lack of bias. Data from the Dugway area were used to represent the pre-pond conditions at the UTTR North Range, and data from the Salt Lake City (SLC) International Airport were used to represent post-pond conditions at the range. Due to the relative distances from the Great Salt Lake (GSL), conditions at Dugway and the North Range are likely to be similar. The use of Dugway as a pre-pond surrogate is likely to be accurate, and well within the typical climatological variations in the area. Data from the SLC airport are likely to overestimate the effects of the proposed ponds, due to the size differential between the surface areas, the depth (and subsequent temperature differentials), and the fetch of typical wind movements over the

bodies of water. However, the SLC airport data are the best available, and are unlikely to grossly overestimate the impacts of the proposed ponds on the flying conditions at the UTTR North Range.

A.2.1 DATA

Climatological data from the Dugway and SLC stations were obtained from the National Climatic Center, Ashev.'le, North Carolina. The data were on magnetic tape, in the TD-1440 format. The data analyzed represented the largest continuous blocks available, and were from January 2, 1948 to December 31, 1983 for SLC, and from December 8, 1949 to December 18, 1970 for Dugway. Data from Dugway were not always reported on a 24 hour basis, resulting in a total of 315,576 hours at SLC and 184,824 hours at Dugway.

The data were paired by hour for the entire period of record. Matched data were available for 184,476 hours. These data were screened, with invalid (9999) and missing (blank) entries for both visibility and ceiling discarded. The final matched data set consists of 165,825 hours for which data are available from both stations. Due to the interest in restricted conditions during flying hours, a subset of the screened data, consisting of entries between 0600 and 2200 local time, was developed. This "flying hours" subset contains 121,414 entries.

Conditions below minimum are defined as hours with ceilings below 3,000 ft and/or visibility less than 3 miles. These conditions are of principal interest to the Air Force, and were requested by the Air Force as weather criteria for this study. The screened data were sorted as either above or below minimum conditions. Total hours are summed, and reported in tabular form. As the date and hour are always included in the data set, particular

months or years can be quickly analyzed to determine the occurrence of below minimum conditions for particular time periods. Because ambiguous conclusions concerning the effects of either stagnation or cyclonic conditions have been drawn in earlier studies of this problem, no attempt to sort minimum conditions was made. The data presented in this study represent total restricted hours, regardless of synoptic features present at the time of observation.

A.2.2 RESULTS

The results of this study consist of a number of tables representing the number of hours that conditions below minimum occur during a time period of interest. These time periods are selected to determine the effects of either weather conditions on flight operations during certain critical periods, or the impact of distance from the proposed ponds on the frequency of minimum conditions. In addition to the data presented in the tables, days with more than 3 hours of restricted flying conditions were determined. This subset was determined by screening each day with below minimum conditions, summing the number of restricted hours, and counting the number of days with more than 3 hours below minimum. In each case, the difference in restricted hours between pre-pond conditions (Dugway) and post-pond conditions (SLC) is assumed to represent the effects of the proposed ponds.

A.2.3 CONCLUSIONS

Based on the analogy between Dugway as a pre-pond North Range and SLC as post-pond North Range, the number of hours restricting flights over the range will be increased as a result of pond formation. Based on historical

data (late 1949-1970), the total number of restricted hours will rise from roughly 410 hours per year to 745 hours per year. The number of restricted hours during typical flying hours will rise from roughly 310 to 545 hours per year. However, neither the number of restricted hours nor the increases are evenly distributed throughout the year. Maximum increases are in the late fall through winter (Nov-Mar), where the total restricted hours are roughly 320 hours for pre-pond and 645 hours for post-pond conditions. Restricted flying hours show similar changes, with pre-pond representing 240 hours, and post-pond representing 470 hours below minimum conditions in the winter period (Table A.1). In each case, the difference between pre- and post-pond conditions is assumed to represent the effect of the proposed ponds. Tables A.2 and A.3 summarize estimated monthly restricted hours for all hours and for flying hours, respectively (21 years of data). Figures A.1 and A.2 illustrate the monthly trends of the data.

To estimate the importance of the proximity of the lake to the reporting station, data from a dry period (1960-1964) are compared with data during a wet period (1979-1984), taken from the North American Weather Consultants (NAWC) study (NAWC 1985). The distance from the lakeshore to the SLC airport changed from roughly 5 km during the dry period to roughly 1 km during the wettest period. This comparison will provide some crude measure of the effect of the proximity of the proposed ponds' shoreline on hours of restrictive weather conditions, as well as the effect of the Lake itself on weather as opposed to overall climatic influences. This information will help in assessing the potential effects of the ponds on operations in the South Range or otherwise removed from the proposed ponds. If Dugway data increase at the same rate as do the SLC data, changes are due

Table A.1 Comparison of pre-pond and post-pond restricted hours at the UTTR North Range for various data records* (all data in hours)

Data Record	Total Hours	Hours Below Minimum Pre-Pond	Hours Below Minimum Post-Pond	Hours Below Minimum Pre-Pond Above Minimum Post-Pond	Hours Below Minimum Post-Pond Above Minimum Pre-Pond	Hours Below Minimum Both
All months, all hours	165,825	8,548	15,642	3,105	10,199	5,443
All months, flight hours**	121,414	6,521	11,471	2,543	7,493	3,978
November-March, all hours	69,183	6,715	13,528	2,024	8,837	4,691
November-March, flight hours	50,439	4,989	9,849	1,618	6,478	3,371

*All values reflect 21 years of data.
**Flight hours are 0600-2200 hours.

Table A.2 Comparison of pre- and post-pond flying conditions by month, total number of restricted hours, all data (all data in hours)[a]

Month	Total Hours	Below Minimum Pre-Pond	Below Minimum Post-Pond
Jan	14,513	1,504	3,830
Feb	13,035	1,257	2,148
Mar	13,711	922	1,206
Apr	13,102	742	1,122
May	13,537	475	370
Jun	13,786	230	128
Jul	14,269	26	5
Aug	14,151	36	38
Sep	13,660	69	90
Oct	14,137	255	361
Nov	13,528	670	1,731
Dec	14,396	2,362	4,613

[a] All values represent 21 yrs of data.

Table A.3 Comparison of pre- and post-pond flying conditions by month, total number of restricted hours, 0600-2200 (all data in hours)[a]

Month	Total Hours	Below Minimum Pre-Pond	Below Minimum Post-Pond
Jan	10,539	1,096	2,775
Feb	9,474	946	1,540
Mar	10,053	758	894
Apr	9,652	611	853
May	9,970	394	278
Jun	10,130	195	96
Jul	10,472	26	5
Aug	10,377	30	29
Sep	10,008	59	76
Oct	10,366	217	285
Nov	9,883	509	1,279
Dec	10,490	1,680	3,361

[a] All values represent 21 yrs of data.

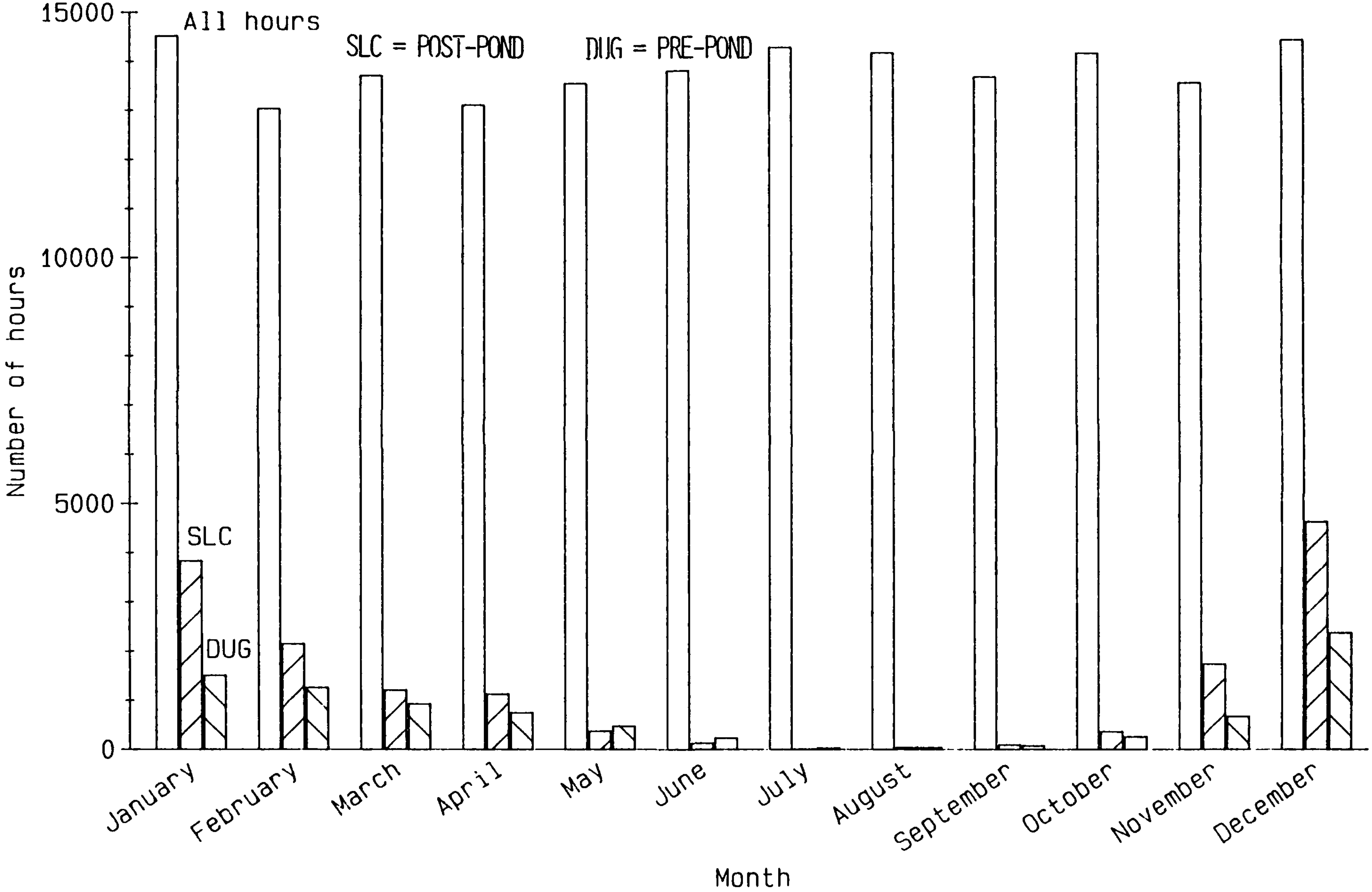

Figure A.1. Comparison of pre- and post-pond weather conditions by month, all hours

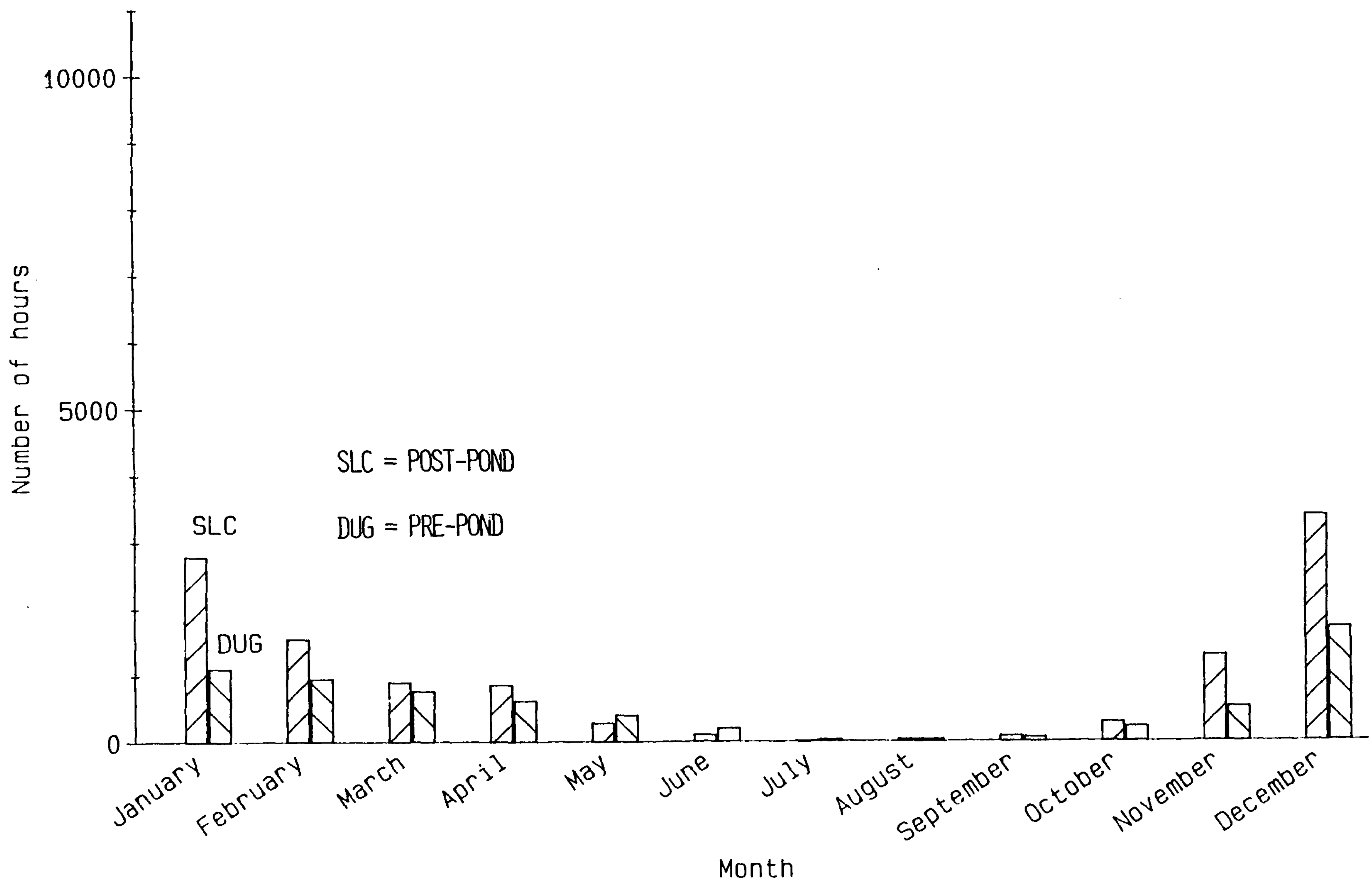

Figure A.2. Comparison of pre- and post-pond weather conditions by month, flying hours

to overall climatic influences. Conversely, if SLC data change more than Dugway, proximity to the Lake does indeed influence minimum conditions. Other factors, not considered in this crude test, undoubtedly affect the conditions at both locations. However, the greatest impacts are likely to result from lake size and shore location. NAWC could demonstrate no changes in conditions due to fetch, which implies that distance to shoreline should be the overriding influence in any changes. During the dry period (greater distance between lake and airport), Dugway averaged 480 hours per year below minimum (5% of total hours), while SLC reported 940 below minimum hours (11% of total hours) per year. During the wet period of 1979-1984 (shorter distance between lake and airport), Dugway reported 7% below minimum, while SLC reported 16% below minimum hours (Table A.4). Based on this crude technique, it can be stated that proximity to lakeshore is important, that the effects of the GSL dominate regional effects on flying conditions within a few kilometers of the Lake, and the use of the SLC data as a surrogate for post-pond North Range conditions is reasonable. From these results, it is estimated that UTTR activities located in the northern 5km of the South Range could be affected to some extent by the ponds. Activities south of this area are not likely to be significantly affected by below minimum weather conditions caused by the ponds.

To estimate the effects of the proposed ponds on missions at the UTTR, the number of days with more than three hours of restricted conditions was determined. Based on the November to March period of record, when present flying operations are most impacted by weather conditions, post-pond conditions represent approximately 52 days per year with more than 3 below-minimum hours, while pre-pond averages approximately 28 days. During

Table A.4 Effect of proximity to shoreline on below minimum weather conditions (all data in hours)

Data Record	Total Hours	Below Minimum SLC	Below Minimum Dugway	Below Minimum SLC Above Minimum Dugway	Below Minimum Dugway Above Minimum SLC	Below Minimum Both
1960-1964,* all hours	43,844	4,707	2,394	3,189	876	1,518
1979-1984,** all hours	9,863	1,578	652	1,080	154	498

*Long distance to shoreline
**Short distance to shoreline

the 0600-2200 hour flying times, post-pond conditions represent roughly 44 days with multiple below-minimum hours, while pre-pond averages about 24 days during the same hours. Based on this very rough analysis, flight operations at the UTTR could be curtailed as much as 20 additional days per winter time period due to adverse weather from the proposed ponds.

Estimating the effects of the proposed ponds on flying conditions at the UTTR North Range is complex. The processes that could influence the meteorology are varied, and impossible to accurately quantify. The lack of unbiased data at the Range increases the uncertainty in the analysis. However, based on the data available, changes in conditions at the North Range appear certain to occur due to the presence of the ponds. Conditions at the SLC airport are likely to represent a realistic worst-case estimate of the post-pond flying restrictions at the range complex. The ponds are likely to result in a noticeable increase in flight restrictions at the range during the fall and winter months. It can be further postulated that the effects of the ponds will be reduced with distance from the shoreline, with effects reduced markedly beyond several kilometers from the water's edge.

A.3 REFERENCES

North American Weather Consultants (NAWC). 1985. Estimated Impacts of West Desert Pumping Alternative on Local Weather. NAWC Report SLWM 85-1. Prepared for Utah State Division of Natural Resources, April 1985.

APPENDIX B

ANALYSIS OF SURFACE AND GROUND WATER CONDITIONS
AT THE UTAH TEST AND TRAINING RANGE

APPENDIX B

ANALYSIS OF SURFACE AND GROUND WATER CONDITIONS AT THE UTAH TEST AND TRAINING RANGE

This analysis is based on a site visit to Targets 13, 21, 23, and 24 on the Utah Test and Training Range (UTTR, at Hill Air Force Base and on ground water data obtained by contractors for the Utah Division of Water Resources. Ground water levels in piezometers were measured on March 9, 1985 by the State's contractor (Dames and Moore 1985) and site conditions were observed on March 26, 1985, by Oak Ridge National Laboratory (ORNL) staff. In general, ORNL staff concur with the findings of the contractor study, as described below.

The targets are located in a broad basin (the northeastern arm of Great Salt Lake Desert) lying between two mountain ranges, the Newfoundland Range on the west and the Grassy Mountains on the east. This basin is composed of two geomorphically distinct areas, mud flats on an ancient lake bed on the west side and low lying humicky hills composed of sand dunes and loess (eolian deposits) on the east (Fig. B.1). The boundary between the mud flats and the eolian deposits is somewhat irregular.

The targets were laid out among the sand dunes about 0.25 to 1 mile east of the mud flats edge and at 10 to 20 ft higher elevations. A few isolated mud flats lie among the sand dunes. Most isolated mud flats are re-entrants that were blocked-off from the main lake bed by sand dunes. Other isolated mud flats at higher elevation than the main lake bed developed as interior basins within the sand dune complex (for example, the large mud flat on the east side of Target 13).

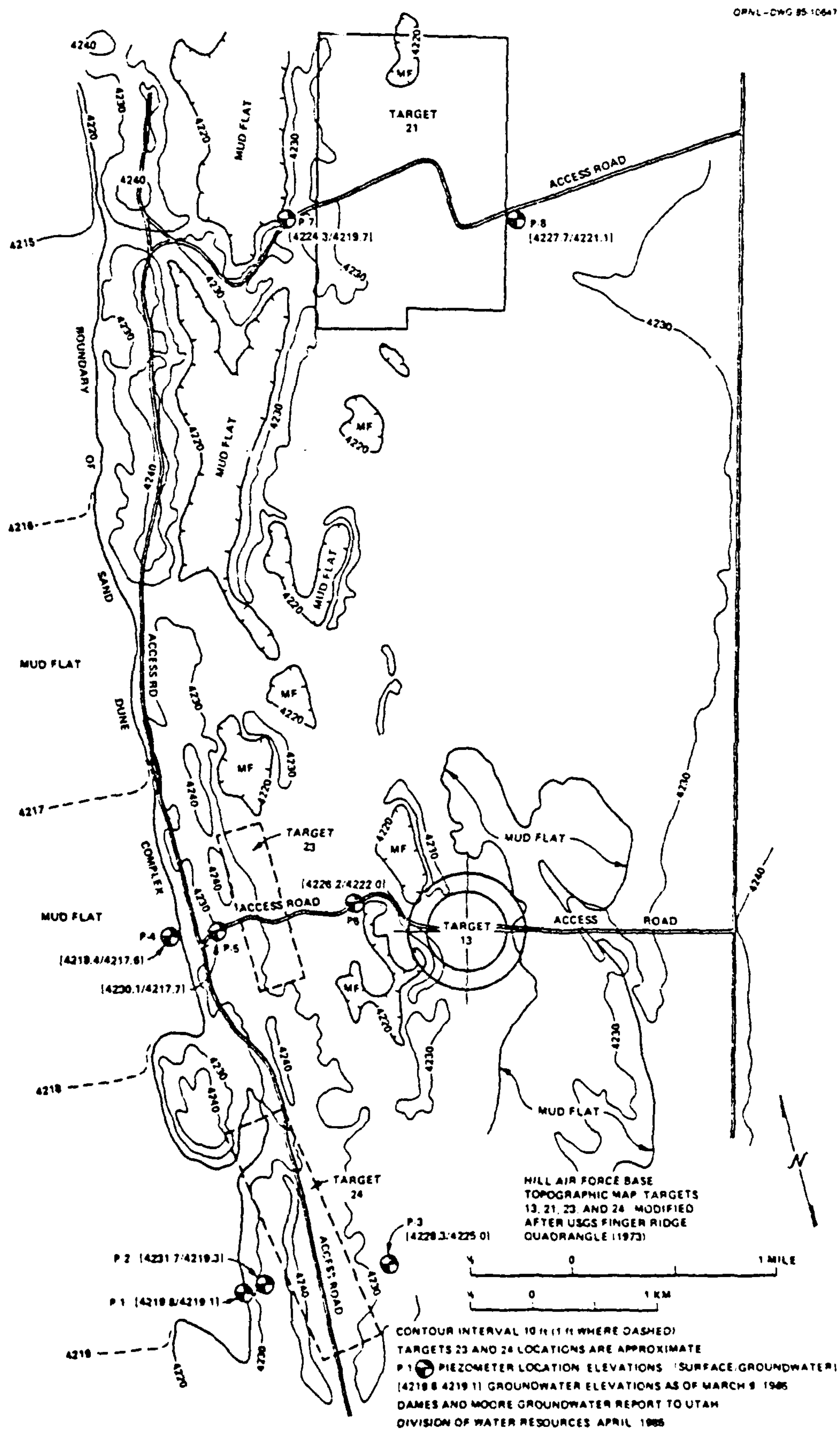

Figure B.1. Geohydrologic features in the vicinity of critical targets in the UTTR North Range

Poor trafficability in the target areas is caused by poorly drained surface water. Water collects in low spots which are not properly sloped or filled-in and at higher elevations where impermeable caliche prevents infiltrating rain or melting snow from reaching the water table.

Natural dewatering mechanisms in the target areas are ineffective. Ground water flow in the adjacent mud flats is virtually non-existent because the basin has no outlet, the piezometric gradient is very low (~1:5000), and the lake bed muds are relatively impermeable (~1 x 10^{-5} cm/sec). Evaporation is capable of removing moisture from only the upper 3 ft of soil and the rate of evaporation is hindered by high salinity. Vegetation is required to remove moisture from greater depths and, where present, it contributes substantially to dewatering soils at shallow depths as well (Romney et al. 1980). However, all vegetation has been removed from the target areas and the nearby mud fla will not support vegetation because of high salinity and year-round saturation of soil by moisture.

In recent years surface water from early spring rains and snow melt accumulated in the isolated basins among the sand dunes. Ephemeral ponds appear in the spring. They gradually change to mud flats which dry out during the course of the summer.

Surface drainage can be improved by installing shallow French drains, reshaping the surface, and filling in low spots. French drains excavated deep enough to completely penetrate the caliche (3 to 4 ft) would direct infiltrating surface water to the underlying water table. The construction cost estimate for French drains that are backfilled with gravel would range between $5.00 and $6.00 per foot of drain length. This cost which does not include ordnance disposal that would have to be performed by the Air Force,

is based on gravel at $10.00 per cubic yard, soil excavation at $4.30 per cubic yard and soil removal at $5.00 per cubic yard. Overhead, profit and contingency costs were included in these unit costs. No open ditches would be required and vehicles could be driven across the drains without damaging them. Ponded water at the north end of Target 21 is in direct contact with ground water. This and other mud flats below an elevation of about 4220 ft as shown in Fig. B.1 would require fill material, as french drains would be ineffective below the water table. The water table does not affect trafficability in target areas above an elevation of about 4225 ft under present conditions. Revegetation is not a viable mechanism for dewatering because explosive ordnance disposal teams cannot work on targets unless they are cleared of vegetation.

The following discussion presents an analysis of the influence of the water table on trafficability after the East Pond is filled to an elevation of 4214 ft. In this context it is important to keep in mind that the seepage rate from the target areas toward the mud flats is controlled by the potential gradient between isolated ponds and the western edge of the sand dune complex.

An East Pond at an elevation of 4214 ft would not cause a rise in the water table beneath the target areas in the early spring. On March 9, 1985 ground water levels were at or near their maximum possible levels (ground surface, from 4215 ft at the Laser Guided Bomb Target to 4220 ft at Target 24) at the boundary between the main mud flats and the sand dune complex. Thus, the seepage rate from the ground water mound to the main mud flats would be the same in early spring whether the East Pond was present or not.

Currently, the annual fluctuation of the piezometric head at the eastern edge of the main mud flats is unknown. Monthly water level measurements through March, 1986, will be required to establish the annual range in water table elevations.

There is a critical need to know the annual fluctuation of the piezometric head at the eastern edge of the mud flats under current conditions. A decline in the water table may be caused by both evaporation and subsurface seepage toward the lowest areas within the mud flats. The magnitude of fluctuation will provide insight into whether evaporation or seepage is the dominant process. As previously noted little or no evaporation takes place at depths greater than 3 ft below the surface. However, a 2 ft drop in the water table can easily be accounted for by evaporation. A greater decline than 3 ft would require a contribution from seepage. If annual seepage toward the center of the mud flats is trivial under current conditions it is difficult to see how the presence of an East Pond will have any effect on the rate of decline of the water table beneath the target areas. If under current conditions the annual fluctuation in the water table exceeds about 5 ft the effect of an East Pond may require reassessment.

Permeability is also a factor in determining the rate of decline of a ground water mound. According to the State's contractor the permeability beneath the caliche is one to three orders of magnitude greater in the sand dune complex than beneath the main body of mud flats (10^{-2} to 10^{-4} cm/sec in the sand dunes in comparison to 10^{-5} cm/sec in the mud flats). Therefore, subsurface flow from the sand dunes to the mud flats should be

relatively rapid until the water table drops below the top of lacustrine sediments (about 4220 ft). Further drainage is impeded by low potential gradient as well as low permeability.

In the long-term ground water may rise significantly beneath the Big Poppa Target if the East Pond is maintained at an elevation of 4214 ft. The ground water level was at an elevation of 4209.9 ft beneath Big Poppa on March 9, 1985. In the long-term the water table elevation beneath Big Poppa is expected to equilibrate somewhere near the elevation of the East Pond's surface. Nevertheless, trafficability will remain unaffected by rising ground water beneath Big Poppa. The lowest surface elevation on this target is 4223 ft, or about 9 ft above the maximum level of the East Pond.

In summary, currently poor surface drainage conditions at Targets 13, 21, 23, and 24 are not expected to be exacerbated by the presence of an East Pond. This conclusion is based on: 1) the fact that ground water on March 9, 1985, was near its maximum elevation at the boundary between the main mud flat and the sand dune complex (nominally, the elevation of the mud flat surface as shown in Fig. B.1); and 2) the assumptions that water levels in piezometers in the mud flat will fluctuate (in response to precipitation and snow melt in the early spring and evaporation during summer and fall) less than about 2 to 3 ft annually. Larger annual fluctuations in water levels would imply a need for re-examining the role of seepage in draining target areas. Currently, ORNL staff do not believe that seepage plays a significant role.

REFERENCES

Dames and Moore. 1985. "Ground Water Hydrology Investigation; West Desert Pumping Project; Great Salt Lake Desert, Utah," in "Facilities and Appurtenances Study Related to the E.I.S. for West Desert Pumping Alternatives," prepared by Eckhoff, Watson, and Preator Engineering, Salt Lake City, Utah.

Romney, E. M., R. B. Hunter, and A. Wallace. 1980. "Vegetation Management and Recovery at Sites Disturbed for Solar Thermal Power Systems Development," Laboratory of Biomedical and Envionmental Sciences, University of California at Los Angeles, California.

APPENDIX C

EVALUATION OF COSTS OF SHORT-TERM LAKE LEVEL MANAGEMENT SCHEMES

C.1 INTRODUCTION

The State of Utah is considering the use of Air Force lands (the Utah Test and Training Range) to create about 500,000 acres of ponds for alleviating flooding problems associated with the Great Salt Lake. The costs and benefits of the proposed use of Air Force lands for the creation of evaporation ponds are important because if the project costs more to construct and operate than the cost of damages expected from rising lake levels, then the project is not worth doing. A number of studies have been completed by the State that suggest the benefits (i.e., reduction in flood damages) from constructing and operating West Desert Pumping outweigh its costs. Evaluating and comparing the construction and operation costs and the flooding damage costs would help to determine if the studies are reasonable and use consistent assumptions, and that the cost estimates and conclusions are valid. In its January 1984 position paper, the Air Force suggested that the West Desert Pumping Proposal feasibility study (Eckhoff 1983) underestimated project construction costs because the study did not include, among other things, the cost of providing explosive ordnance clearing, mobilization costs, inflationary costs, etc. These concerns need to be addressed and updated to reflect current State proposals.

The purpose of this report is to provide an independent, broad-based review of the State of Utah's estimates of the cost of constructing and operating short-term lake level management schemes (West Desert Pumping, and diking of the Great Salt Lake shoreline) and the State's estimates of the damages likely to occur from rising lake levels. The diking of the Great Salt Lake shoreline by itself is expected to have minimal, if any, impact on UTTR operations, and is included in this report primarily as an additional source of cost estimation data that can be used as a consistency check in

evaluating the costs of the West Desert Pumping Proposal. The diking study also contains some information on damages expected from flooding, and thus is briefly addressed in the evauation of damage estimates.

C.2 REVIEW OF WEST DESERT PUMPING FEASIBILITY COSTS

C.2.1 1983 FEASIBILITY STUDY

The Proposed Action Plan issued by the Utah State Land and Forestry Department[2] in December 1984 identifies West Desert pumping as the most feasible and cost effective proposal for influencing the Great Salt Lake water level. Several options were developed for implementing the West Desert Pumping Proposal,[3] but the state prefers the South Railroad Lowline Alternative, Return Brine North Option, as identified on the 1983 feasibility study for West Desert pumping. In 1984, the State of Utah asked Eckhoff, Watson and Preator to update the 1983 feasibility study to evaluate the West Desert Pumping Proposal with respect to the higher lake level and to assess ways of mitigating potential impacts to the UTTR. The 1984 update[4] was primarily used by the state to develop alternatives to the state's preferred West Desert pumping option identified in the 1983 feasibility study and did not contain much new information in the state's preferred option. Consequently, this section will focus primarily on the initial 1983 study, and will address the state's preferred option as described in the 1983 study.

The state's preferred West Desert pumping option proposes to take water from the south arm of the Great Salt Lake and pump it onto the desert to the west of the lake where evaporation will occur. The remaining water will be drained back to the north arm to help control the brine content in the evaporation ponds.

In 1983 this concept was developed to include an east and west pond, pumping station and outlet siphon with associated dikes, canals, bridges and structures. The total cost for this construction was estimated at approximately $36 million.

Since the estimate and design were prepared, the level of the Great Salt Lake has continued to rise. This effect has already changed parts of the design related to the intake canal.[8] The cost impact of these changes on the original estimate have not been revised in detail for the project.

This cost estimate evaluation is based on the cost estimate given in Table II-4 of reference 3 for the South Railroad Lowline Alternative, Return Brine North Option which has a capacity of 2400 cfs. Also included in this study are comments on cost items which were not included in the original estimate as well as situations that have developed since 1983 that could adversely influence the project cost.

Four major cost categories have been identified in the 1983 report, with a total estimated cost of $36 million. Of the total cost, 24 percent was estimated for the pumping system, 63 percent for the earthwork, 7 percent for railroad bridges and 6 percent for other structures and facilities.

Pumping System

The 2400 cfs pumping system was addressed in great detail in Ref. 3 with particular emphasis on the capital and system operating costs. Any error in this cost estimate could only be revealed during the actual design phase of the pumping system when specific details of the construction would be identified. The cost estimate for this work appears, therefore, to be reasonable and satisfactory based on 1983 costs.

Earthwork

The earthwork is by far the largest single cost item for the project. Excavation, embankments, riprap and backfill have been identified as operations in this cost category. The quantities of materials which were reported in Ref. 3 have been assumed correct and accurate since insufficient design detail is available for a cross check on the quantity take-offs. The unit cost for the various items were, however, examined.

Most of the earthwork consists of handling soil and rock in the immediate vicinity of the particular construction site. When transportation of materials was required, a higher unit cost was assigned. In addition to these facts, the unit cost would be expected to be lower than normal because the area is rather flat and no vegetation exists which would require grubbing, clearing and burning. These unit costs therefore are based on the assumption that the least expensive means for performing the earthwork can be employed.

One factor which will influence the actual construction cost and which was not considered in the 1983 study has recently developed. The rising level of the Great Salt Lake may necessitate some potentially costly construction techniques such as dredging, barging and dewatering. These methods are far more expensive on a unit cost basis than the assumed methods of construction. Since details of design and construction methods would vary as a function of lake level, no attempt to estimate these additional costs has been undertaken in this evaluation.

Railroad Bridges

No details of design or specification for a railroad bridge construction were provided in the 1983 study, although it is stated that these bridges will be located in the West Desert and in the Great Salt Lake.

A unit cost of $10,000 per foot for lake bridges and $2,000 per foot for land bridges was stated, but without more specific information on this aspect of the project, a check on the validity of this cost could not be performed. These costs are assumed to be reasonable, however, since the cost of the SPRR breach which was completed in August 1984 within the difficult lake environment was about $10,000 per foot.

Structures and Facilities

The structures and facilities for this project are the least costly items in the project. The type of work and quantities of materials that are required are identified in the 1983 study, but since insufficient design detail has been provided, only a check on unit costs were performed. The unit costs used in the 1983 study for such items as concrete, sheet piling, gravel bedding, concrete pipe, walkways, bridges and gates appear to be reasonable. Factors which may not have been included in these costs are mobilization and demobilization costs, remote location, and accessibility limitations which would affect productivity and the potential for water related problems created by the increased lake level.

Significant errors in unit costs for this part of the project, however, would not seriously affect the total job since it is such a small part of the total.

Explosive Ordnance Disposal

Detection and removal of explosive ordnance, which was not considered in the feasibility studies, could add to the estimated project costs. Explosive ordnance removal would apply only to the Newfoundland Dike portion of the project. Principal components of the cost of the work, which can only be completed by trained U.S. Air Force explosive ordnance disposal (EOD) are the size of the area to be cleared, the type of clearance (surface

vs subsurface), the number of personnel, and equipment supplies. It is assumed that the proposed Newfoundland Dike will be built entirely on UTTR North Range land, and that it will be approximately 8 miles long and 50 ft wide; however, to provide an adequate margin of safety for dike construction crews, an area 8 miles long by about 200 ft wide (about 200 acres) would be cleared. This area could be examined in about 10 days for a surface clearance. For subsurface clearances (3 ft and 15 ft deep), about 25 days would be required to locate buried munitions. About 40 days would be required to recover and demilitarize any buried munitions at a depth of 15 ft, and about 35 days would be required to perform these activities for munitions buried at a depth of 3 ft. Munitions location and disposal requires 8 and 9 personnel, respectively.

Estimated costs for the most expensive ordnance disposal (15 ft subsurface clearance) approach $500,000, but represent about 1% of the total 1985 estimated project costs ($52 million), and about 17% of the 1985 Newfoundland Dike construction cost ($2.9 million).[8] Table C.1 summarizes the costs of surface, 36-inch and 15-ft clearances by EOD personnel for the proposed Newfoundland Dike. As can be seen, costs for the subsurface clearances are at least a factor of 10 greater than those for the surface clearance. Furthermore, all of the subsurface clearances attempted may not be successful because of the high water table in the project area. Because of the high cost and expected difficulty of subsurface clearance, it is recommended that an intense surface clearance be completed before construction (at a total cost of about $39,000), and that any munitions uncovered by construction crews be transferred to EOD personel for disposition. The cost of a surface clearance would add only 2% to the estimated Newfoundland Dike construction cost.

Table C.1 Estimated Costs of Selected Explosive Ordnance Disposal Techniques for the Proposed Newfoundland Dike (1985 dollars)

	Surface Clearance	36 Inch Subsurface Clearance	15 Foot Subsurface Clearance
Days Required	10	35	40
Number of Personnel	8	17	17
Composite Pay and Per diem	$ 8,540	$ 52,600*	$ 60,075*
Military Billets	$ 320	$ 1,960	$ 2,240
Specialized Equipment	$ 9,200	$279,650**	$341,600**
Explosive and Associated Equipment	$ 12,060	$ 13,050	$ 14,151
Supplies	$ 9,095	$ 21,560	$ 24,621
Total	$ 39,215	$368,820	$442,687
Cost per Acre:	$ 196	1,844	$ 2,213

*Assumes 8 people for 25 days (detection) and 9 people for 40 days disposal).
**Assumes salvage value of equipment as follows: forrester, 90%; shaft liner kit, 50%; crew cabs, 70%; backhoe, 70%; pumps, 70%. All other equipment assumed to have no salvage value.

C.2.2 1985 UPDATE

In early 1985, the engineering design and construction aspects of the state's preferred option were re-examined to develop updated construction schedules and cost estimates. In particular, the 1985 update[8] reflects the influence of a higher lake level, greater insight into local soil and water table conditions, and accessibility limitations due to the remote nature of the sites. The total construction cost for the state's preferred option is now about $52 million (an increase of about $16 million over the 1983 feasibility study).

This section examines the design changes required because of the increased lake level and evaluates the basis of the revised cost estimates.

Some construction aspects of the project are discussed along with any inconsistencies and omissions from the cost estimates. The section is organized according to the major components of the 1985 report.

Mobilization

The report[8] recognizes the potential need for establishing a base camp for the labor force, and that the lack of facilities, roads, fresh water, power and construction materials and the need for heavy equipment service and maintenance vehicles at these remote sites must be included in the project scope. Discussion about the need for interfacing with railroad personnel have been included along with comments about various contracting options. All of this uncertainty is not, however, reflected in the construction cost estimate since no estimate for mobilization, management fees or other contingency costs have been included. Cooperation with the Air Force was also not discussed in the report.

Access

An access road parallel to the Southern Pacific Railroad tracks has been proposed as a means to facilitate construction of the dikes, pump station, siphon and canals along the 12 miles of track just west of Lakeside. This upgrade is estimated at $375,000 per mile, and if properly designed, could function as protective dikes for the railroad tracks as well.

This concept was not originally included in the 1983 study[3] but appears feasible as well as desirable from a constructability viewpoint.

Intake Deflector Dike

The proposed intake deflector dike extends west for 10,750 ft from the railroad breach. This dike serves as one side of the intake canal and has a top elevation of 4215 ft. The proposed construction technique of end dumping

of fill materials followed by installation of a filter cloth, cobbles and riprap appears very difficult. All of this work would be done below water or very near the water surface. The cost estimate for the dike (excluding the railroad bridge) is $1.73 million per mile and appears very conservative for this most difficult type of construction (installation of filter cloth under water for $1.00/sq. yd appears unreasonably low). Bearing capacity, settlement and dike maintenance are issues that are not addressed but could affect the proposed design configuration and construction cost. More detailed designs based on field investigation are required before a more reliable cost estimate could be prepared for the intake deflector dike.

Intake Canal and East Barrier Dike

The design of these two items has been affected by the rise in lake elevation since the 1983 study[3] was conducted. The total amount of excavation, riprap and backfill that is now required has been significantly reduced. The East Barrier Dike must, however, be partially constructed below water, which is a somewhat more difficult type of construction than is implied in the report. The estimated cost for the East Barrier Dike fill material of $5.75 per cubic yard versus $8.16 per cubic yard for the Intake Deflector Dike fill, and the cost of $7.50 per cubic yard for East Barrier Dike riprap versus $11.94 per cubic yard for Intake Deflector Dike riprap are not consistent.

The Intake Canal is to be constructed by dredging. The unit cost of dredged materials, estimated at $1.[illegible] per cubic yard, does not include mobilization and demobilization costs of the dredging equipment. The report states that the mobilization time for the dredge could be as long as 90 days. This cost factor should be included in this line item.

Pumping Facility

The pumping capacity of 2400 cfs established in 1983[3] has not changed in the 1985 updated design.[8] The pump station is the source of the largest component of the projects operation and maintenance costs. Two pump scenarios have been studied: 12 hydraulic drive pumps vs 3 direct drive pumps. The total operation and maintenance costs for 12 Cummins 1,000 HP pump engines are about $4.2 million/yr, and for 3 Caterpillar 4,000 HP engines are about $3.6 million/yr. Construction cost estimates are based on the 3 pump scenario.

Outlet Siphon

The elevated lake level has changed this design and cost estimate. Less concrete pipe is now required but the site must be dewatered to install the pipe. Also the outlet canal must now be dredged before the riprap is installed. The unit costs for riprap do not reflect the added expense of underwater installation and no estimate for dewatering has been included.

Discharge Canal

Conglomerate and limestone must be excavated through the Hogup Ridge to construct the discharge canal. This was anticipated in the 1983 study[3] since that estimate of $5.00 per cubic yard reflected blasting and ripping costs. The present cost estimate and design configuration however are subject to change when more detailed information on the geology along the alignment is known.

Railroad Dikes

The design of the railroad dikes has not changed since the 1983 study.[3] The cost estimate, however, is much higher now reflecting the new requirement of compacted backfill at $5.73 per cubic yard instead of on-site

native materials at $1.25 per cubic yard. These dikes are 22 miles long and represent a significant part of the overall project cost.

Bonneville Dike

This design is the same as the 1983 study[3] and will be built from native materials. Some difficulties with equipment access are indicated in the report but no estimate of the impact on costs is estimated. This item cost estimate is therefore considered low because of these known uncertainties. Also, in reference 8, Appendix C, which gives unit cost data for project components, does not agree with Table 7.1 for the cost of backfill for the dike. The appendix assumes compacted backfill at $5.73 per cubic yard, and Table 7.1 assumes backfill at $2.00 per cubic yard.

Newfoundland Dike and Control Structure

This phase of the project is also essentially the same as the 1983 study.[3] The principal difference is that current plans call for the construction of a 5 ft deep by 2 ft wide cut-off wall in the dike. The 8 mile dike must be constructed on Air Force property which has limited access and only unimproved roads to the dike area. The cost estimate does not reflect additional expenses for these factors and is therefore considered low.

C.3 REVIEW OF GREAT SALT LAKE DIKING FEASIBILITY COSTS

In late 1984 a feasibility study[5,6,7] was conducted by James M. Montgomery Consulting Engineers, Inc., for the State of Utah, Department of Natural Resources, Division of Water Resources. Various diking concepts were proposed to control flooding which would occur if the level of the Great Salt Lake would continue to rise. The various proposed diking alternatives, which extend from the southern to the eastern shores of the Great

Salt Lake, were examined to determine their feasibility of construction, initial capital costs, operating and maintenance costs and their benefit value to the protected properties. Finally, all of the capital costs, annual operating costs, annual maintenance costs and benefit values were tabulated for each diking alternative. The feasibility study concludes by recommending the preferred alternative from each of the in-lake and near-shore options.

This evaluation focuses attention on the methodology which was used to formulate the estimates for the various diking alternatives and examines the basis of the costs and benefits identified in the report.[5] An examination of the subjective factors used to compare the various alternatives is, however, beyond the scope of this evaluation.

The objective of this cost estimate evaluation was to examine the basis of the costs and benefits identified in the feasibility study.[5] The costs that were examined included the dike construction costs, pumping station capital costs, operating costs, and maintenance costs. The benefit value placed on the properties protected by the proposed diking systems were also considered although little specific data were supplied in the study to evaluate its accuracy.

To accommodate the large number of estimates required to evaluate the various diking alternatives, a systematic estimating approach was developed in the feasibility study.[5] The four diking options examined, which are 1) In-Lake dikes, 2) Box Elder and Weber County dikes, 3) Davis and Salt Lake County dikes, and 4) Tooele County dikes, were proposed with several alternative dike segments developed for each option. From these various alternatives, 23 dike segments were identified. Each segment was examined for dike construction feasibility, capital cost, operating cost, maintenance cost

and benefit value. Each alternative diking system estimate was then assembled by adding appropriate segment costs and benefits.

Factors which varied for each segment from one alternative to another such as dike length, dike elevation, pumping station size and estimated dike settlement were accommodated by a computer code. By using these segments as building blocks, tables for each alternative, which included capital costs, operating costs, maintenance costs and benefit values, were systematically developed.

C.3.1 CONSTRUCTION COSTS

The cost per cubic yard of diking material was developed by adding charges for material acquisition, loading, hauling, and placing. In the case of riprap, drilling, shooting and sorting costs were included. These unit costs were prepared for each of the 23 segments of the project. An overhead charge of 26 percent was also included in the total segment unit cost. Table C.2 identifies the maximum and minimum unit costs for the three types of diking materials.

Table C.2 Estimated diking material unit costs for various locations

Material	Maximum $/cu. yd.	Minimum $/cu. yd.
Granular borrow	8.81	2.66
Riprap	32.50	13.70
Riprap filter gravel	28.30	4.30

These costs were based on the unit costs identified in Table 11-1 of Ref. 5, which were developed from input from three different organizations.

The wide cost variations exist because hauling distances from the diking material source to the various dike segments were different for each segment as were the placing costs. Placing costs for riprap and filter gravel varied from $\$2.43/yd^3$ on shore to $\$15.00/yd^3$ in the lake.

From these unit cost figures, the cost of each segment of the project was computed by multiplying the quantities of each material required by the appropriate unit cost. The quantities were determined based on the dike design geometry, required dike elevation, base elevation variation, estimated settlement and total segment length.

The pumping station costs were estimated from eight similar pumping stations which were under construction in 1983-84. These estimates included allowance for design costs, construction management and contingencies. Right-of-way or property purchase costs were not included since most of the facilities would be located on public lands.

The basis of the construction cost estimates appears very reasonable. Three estimating groups, including one construction company, provided input into unit cost estimates for diking materials. A computer program was used to determine material quantities. Contingency costs equal to 26 percent were also included. The estimates were particularly sensitive to hauling costs which depended on the distance from the material source. Further study into this project should focus attention on material source locations with emphasis on reducing haul distances.

Items which did not appear in the diking system construction cost estimates included land acquisition or right-of-way costs, engineering design costs, soil sampling and testing costs and legal fees, permits, insurance, mobilization and demobilization costs. These items were, however, taken into consideration in the final cost summaries by including

another 25 percent project contingency factor (overhead) to the total construction cost estimate.

The one factor that could seriously affect the cost estimate for the diking system is the actual amount of settlement the dike would experience during construction. The assumed settlement factors used in the study were not based on actual test data, but rather on experience. Efforts to substantiate this assumption would be required before an actual construction cost estimate could be performed.

The pumping station cost estimates are reasonable for this phase of the project.

C.3.2 OPERATION AND MAINTENANCE COSTS

Operating and maintenance costs are required to run pumping stations and maintenance costs are required for the dikes themselves. Unit costs were developed for annual maintenance fees for the dikes and for the pumping station. These unit costs were then assembled for each diking alternative.

Dike maintenance is required due to the settlement of the dikes with time. Table C.3 identifies the estimated maintenance costs for dikes located on the three types of soils in the project.

Table C.3 Dike maintenance cost estimate[5]

Soil Type	Assumed Settlement (Feet/Yr)	Annual Maintenance Cost ($/Mile)
Poor	1.5	160,000
Fair	1.0	108,000
Good	0.5	54,000

The unit cost reflects charges for dike materials and riprap which would be transported in small quantities over a period of time. These costs are also much higher than the initial construction costs due to the smaller quantities of materials involved.

Pumping station maintenance costs and operating costs were assumed to vary with the size of the pump station. Manpower costs for operation and repair and electricity and fuel costs were included in the estimates for each pumping station.

The annual operating and annual maintenance costs were presented in the report[5] for each diking alternative. These estimates reflect the major cost factors and appear reasonable based on the feasibility stage of this project.

C.4 EVALUATION OF FLOODING DAMAGE COST ESTIMATES

The two published studies of damages from rising levels of the Great Salt Lake that are of most interest are those done by the University of Utah Bureau of Economic and Business Research and James Montgomery Engineers (done as part of the diking study).

C.4.1 UNIVERSITY OF UTAH STUDY

The University of Utah Bureau of Economic and Business Research has performed two studies of the actual and potential damages caused by elevation of the Great Salt Lake. The first study,[9] prepared for the Utah Dept. of Natural Resources, Division of Water Resources, assessed the damages caused by 1983 by the rise of the water level to 4205 ft MSL, and estimated the additional damage that would be experienced with each

additional one foot elevation in lake level, up to 4212 ft MSL. Four categories of damages/costs were examined: 1) capital investments/capital losses, 2) annual revenue decreases of private firms, 3) annual household income losses and 4) annual tax revenue reductions to state and local governments.

Capital damage were construed to include investment in flood control measures (diking, sandbagging, pumping), replacement costs, original costs and cost of constructing improved structures. Costs for flood control measures were used if these appeared likely to protect facilities from being destroyed. Replacement costs were considered if structures were likely to be restored to original conditions (e.g., roads, public utilities). Original costs, rather than replacement costs, were used in the event of complete destruction of facilities which probably would not be replaced.

Seven potentially impacted areas were studied: 1) lakeside industries (salt companies), 2) roads and highways, 3) railroads, 4) waterfowl management areas, 5) recreation areas, 6) public utilities (power, telephone), 7) other public utilities (sewer treatment plants, airports). In each case, consultation was held with the appropriate authorities to obtain their best estimates of damages, replacement costs, etc.

A second study in 1984 for the U.S. Economic Development Administration[10] examined damages from flooding (and landslides) that would be caused by one-foot increments in lake elevation up to 4215 ft. At the request of the sponsoring agency, this study did not consider revenue losses incurred. A table from the report shows that additional impacted areas were studied: Other Industry, Residences and Agricultural Buildings.[11] Damage to residences does not appear until an elevation of 4213 ft. Economic ripple effects due to job losses are not taken into

consideration. Capital damage to the mineral industries is not entered for elevations above 4211 ft, since at this point, they are a total loss.

C.4.2 DIKING STUDY

The Damage Assessment section in Chapter 8 of the Great Salt Lake diking study[5] states that the basis for assessing potential damages is a no-action assumption, that is, it addresses the damages that could be expected at the 4212 ft and 4217 ft levels if no protective measures were taken. Then, stating that such a no-action scenario is non-existent because efforts will certainly be made, individually and collectively, to protect investments, the values of land and facilities are derived.

In general, this method would tend to overstate damages because there would certainly be a tendency to take all actions whose costs were less than the costs avoided (i.e., protection costs as opposed to replacement costs). The costs used in calculating damages appear to be complete replacement costs, rather than avoidance or repair costs.

Another assumption made is a standard maximum impacted zone for the two lake levels considered (4212 ft and 4217 ft). This zone is assumed to extend 6 ft above each level. One hundred percent damage is assumed at and below levels 4212 ft and 4217 ft, and 50% loss in the 6 ft zone above (periodic inundation zone subject to wind and wave action). This assumption alone can greatly increase damage estimates. The University of Utah study[9] considered wind and wave damage to dikes, breakwaters and roads at a distance only 2 ft above the lake level.

No attempt was made to evaluate revenue losses (loss of business, payroll, taxes, etc.) as was done in the University of Utah study. This would appear to be a point of major divergence in the two approaches used.

A very methodical approach was taken in quantifying "improvements". USGS 7.5 minute quadrangle maps, land-use planning and other maps were used to identify roads, canals, dikes, etc. Aerial photography and surveys updated the maps. Single mile sections, identified by township, range and section, were evaluated for land use and improvements, and values were assigned to land, buildings, roads, etc. within each square mile. The values placed on the buildings, roads, etc., as already noted, appear to be replacement costs most probably derived by standard engineering equations for calculating construction costs.

In some instances, the strict use of replacement costs does not seem appropriate. For example, irrigated agricultural crop land was valued at an average current market price of $2,000/acre, and pasture land at $1,200/acre. These are not replaceable items; loss of revenue from crop production would seem a more appropriate statement of damage for the time the land is inundated or recovering from inundation and unavailable. Total damage at the 4212 ft level is expected to be $800 million, without some protective action. At 4217 ft the damage to facilities and improvements was estimated to be $1.5 billion.

The value of the property which would be protected by a diking system was estimated for each dike segment. This estimate has been identified in the report[5] as the "Benefit (Damage) Value." Although no procedure for determining these values was identified, the estimates include only the value of the property which would be protected and does not include secondary or intangible benefits. The report also states that the damage reduction/cost ratios are not equivalent to the benefit/cost ratios commonly used to evaluate economic feasibility.

C.5 SUMMARY AND CONCLUSIONS

C.5.1 WEST DESERT PUMPING

1983 Feasibility Study

The West Desert Pumping Alternative[3] study which was performed in 1983 was an attempt to examine the feasibility of a proposal to help influence the level of the Great Salt Lake. In addition to examining the project feasibility, some preliminary design efforts were undertaken to serve as a basis for a cost estimate. The study concluded that the pumping alternative was feasible and would cost about $36 million.

One of the assumptions that was used to estimate the project cost was that the lake elevation at the time of construction would be at its 1983 elevation or lower. The fact that the lake has risen since the study was performed has therefore created a need to redesign some parts of the project and then to re-evaluate the original cost estimates. Some of the unit costs would no doubt increase, particularly those in which excavation beneath water would be required.

It is recommended that the detailed cost estimates for the project clearly identify adjustments for inflation, contingency costs, and overhead and profits, and that these estimates appear as line items in the total cost estimate for the project. If a 25 percent contingency factor to cover the costs of mobilization/demobilization, remote location and accessibility limitations, and unknown or unforeseen events is added along with another 20 percent for overhead and subcontractor profit. The project cost estimate could approach $55 million (not including adjustments for inflation).

Other fees for land acquisition, permits, legal fees, engineering costs for design, field evaluation efforts and environmental impact statements are

also part of the total program costs but cannot be directly related to construction costs.

1985 Update

The difference between the 1983[3] and 1985[8] studies (Table C.4) reveals impacts of the elevated lake level on construction techniques and costs. Uncertainty such as geologic conditions (i.e., soil, rock and groundwater), the level of the Great Salt Lake at the time of construction, the type of construction contract which will be let, interfacing problems between the State, Railroad, Air Force, Contractor and Suppliers and other unknown factors are again raised in the 1985 study.[8] Much more detail therefore must be placed on this project's design before a more reliable cost estimate can be prepared.

The 1985 cost estimate for the West Desert Pumping Alternative is about $52 million. The elevated lake level has reduced some costs (reduced pumping head and shorter canals) but has also increased some construction costs (dredging, riprap installation, dewatering and material transporting). The level of uncertainty in this cost estimate, however, still remains very high and does not include a contingency factor. In addition, certain factors such as mobilization of dredge equipment, dewatering, organization interfacing and management were identified in the report but have not been included in the cost estimate.

The 1985 cost estimate therefore must be increased to reflect these known charges as well as increased to reflect uncertainties. A 25 percent contingency should be included along with a figure of about 20 percent for overhead and profit. With these factors included, construction costs could run as high as $75 million. If the costs of the known omissions such as ordnance disposal, dewatering, formal agreements between the State of Utah,

Table C.4 Comparison of West Desert Pumping Feasibility Costs, 1983 and 1985

Item	1985 Total Cost $\$ \times 10^3$	Appendix "D", 1983, $\$ \times 10^3$	Table II-4, 1983, $\$ \times 10^3$
1. Intake Deflector Dike	3,981	5,269	2,247
2. Intake Channel and East Barrier Dike	14,890	6,273	7,356
3. Pump Station Discharge Channel	3,308	6,546	6,546
4. Railroad Barrier Dike	9,629	3,169	3,169
5. Siphon	2,762	672	1,371
6. Bonneville Dike	3,018	2,013	2,013
7. Newfoundland Dike & Weir	2,874	1,936	1,936
8. Pumping Plant Alternate 1	7,185	---	---
9. Pumping Plant Alternate 3	6,993	8,770	8,770
10. Upgrading R.R. Access Road	4,500	3,160	2,430
Total (With Pump Alternate 3)	$51,986	$40,664*	$36,338**

*$1,000,000 penalty plus $1,856,000 return brine canal
**$500,000 penalty

Air Force, and railroad organizations, and environmental impact studies are included, the total project cost could approach $100 million.

C.5.2 DIKING

The various diking alternatives[5] provide a number of options for damage control of properties near the Great Salt Lake. The estimates, which included capital costs for construction, benefit (damage) values and operating and maintenance cost estimates, were performed systematically using a well defined methodology. This methodology included appropriate unit costs and quantity data for 23 dike segments, which, when appropriately combined, provided various diking alternative cost estimates. The total project construction cost estimate reflected a 26 percent contingency on material unit costs and an additional 25 percent project overhead contingency. The operating and maintenance cost estimates, which appear reasonable, were prepared to reflect settlement of the dikes with time, energy costs, and operating personnel costs. The benefit (damage) value estimates represented only property values which would be lost if the dikes were not constructed and do not include secondary or intangible values.

The feasibility level of effort placed into this study identified various factors in the project which must be examined in greater detail as the project design continues. These factors could adversely influence the project cost estimates if actual conditions are different from those assumed in the study. Additional soil exploration and testing would be required to substantiate the assumptions used to develop the diking system cost estimates. The dike material availability should also be examined in more

detail since the haul distance is a large contributing factor to the overall diking system cost.

The basis of the cost estimates appears reasonable for this feasibility stage of the project. As additional information becomes available, the reliability of the estimates can be improved from the present level with its 50 percent contingency factor to account for unknown problems and overhead. However, a profit estimate needs to be added to the estimates in the feasibility study.

C.5.3 FLOODING DAMAGE ESTIMATES

A true comparison of the total damage estimates arrived at by the University of Utah and Montgomery studies is not possible, since different assumptions and factors were used in each. At the only elevation common to the two, 4212 ft, the totals are quite different; University of Utah (1983) estimates about $220,000,000, and Montgomery estimates about $800,000,000. The University of Utah value was arrived at by adding a revised value for actual damages incurred at 4209 ft ($176 million) to projected cumulative total damages from 4210 ft to 4212 ft ($44 million).

The 1983 University of Utah study[9] of damages due to lake elevations appears to be a more "hands-on" socio-economic approach to the problem than the Montgomery study. Contacts were made with the potentially affected entities (industries, governments, etc.) and their best estimates of damages were taken into consideration. In addition, revenue losses to industries, workers and governments were factored into the final damages derived for each foot of rise in elevation of the lake. The 1984 study, on the other hand, did not include revenue loss considerations, but did include several affected areas not covered in the 1983 survey.

The Montgomery study appears to use replacement costs as a basis for estimating damages. Likewise, the basic assumption of a no-action situation, which cannot exist in actuality, for determining damages, leads to the use of total capital value and/or replacement costs. The 6 ft zone of 50% damage connected with each of the two lake levels studied (4212 ft and 4217 ft) may exaggerate the damage figures greatly, even without consideration of revenue losses. It is probably for this latter reason that the study cautions against the use of the benefit values for purposes outside the scope of the diking study.

C.5.6 COSTS AND BENEFITS

As indicated by the above discussions, the overall benefits of the West Desert Pumping Proposal (reduced flooding damages) exceed construction costs, based on the information reviewed. The estimated construction cost of West Desert pumping, including assumed costs for contingency and overhead, is about \$75 million at the feasibility design stage. Operation and maintenance costs are at least \$3.6 million/yr (excluding dike maintenance, riprap replacement or channel dredging). The estimated value of damages saved by short-term lake level control is about \$220 million (damages at a lake level of 4212 ft)[9]; actual damages incurred in 1984 when the lake level reached 4209 ft were about \$176 million. Because West Desert pumping is only at the feasibility stage, costs could change as more detailed design work is completed, and as the lake level changes with time. Project construction costs for certain components have increased from the 1983 feasibility study to the 1985 update. The overall apparent costs and benefits could therefore change substantially in the future, and the costs of West Desert pumping could begin to approach or exceed the project's benefits. The lake level selected as

the control for initiating the pumping also influences the benefits expected from West Desert Pumping. For example, if West Desert Pumping were used to protect land above 4210 ft elevation, then the benefits of protecting to an elevation of 4212 ft would be the estimated $220 million for 4212 ft protection less the $176 million in damages that have already occurred up to a lake elevation of 4210 ft. In this case, the benefits would be on the order of $44 million, and may not outweigh the costs of the pumping.

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